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A TRUNK SEWER from Paterson, N. J., to Robbins Reef, in New York Bay, with disposal by dilution, has been recommended by Messrs. Rudolph Hering, J. J. R. Croes and W. M. Brown, Jr., Mems. Am. Soc. C. E., in a report to the New Jersey State Sewerage Commission. The recommendation has been approved by the commission, and is included in its annual report, just submitted to the Governor of New Jersey. The commission, it is reported, also advises that it be given legislative authority to build the proposed trunk sewer and accessory pumping stations, at the expense of the communities served by the sewer. The sewer would be 7 ft. in diameter at Paterson and 11½ ft. at Newark Bay, and the capacity, at its lower end, would be 270,000,000 gallons. At Newark Bay, which is 15.7 miles from the upper end of the sewer, pumps with a total lift of about 40 ft. would deliver the sewage into two 60-in. cast-iron force mains, leading across the bay. The sewer would continue across the Bayonne peninsula and discharge into Upper New York Bay some two miles from shore, in 70 ft. of water. A small pumping plant would be required to lift the sewage of 1,500 acres of low land in and near Passaic. The estimated cost of the whole works, as outlined, but including a main pumping station of 150,000,000 gallons only, and a single outfall sewer into New York Bay with a daily capacity of 100,000,000 gallons only, is $7,000,000. The experts believe that the sewage, in its crude state, could not be discharged into Newark Bay, as proposed by the commission of 1897, without danger of serious offense. They estimate that about $4,000,000 would be required for purification works on the Newark Meadows, consisting of septic tanks and contact filter beds. This, too, assumes the use of open septic tanks. The experts also find that a trunk sewer for the Paterson and Passaic district, with purification works on the Hackensack Meadows, would cost this upper district more than its share of the cost of the proposed joint sewer for the whole valley. The report of the experts is based, in part, upon local studies by Messrs. James Owen, M. Am. Soc. C. E., of Newark, for the lower district, and Colin R. Wise, of Passaic, Robert M. Watson, of Rutherford, and Wm. Ferguson, of Paterson. Mr. Boyd McLean, Fuller Building, Jersey City, is Secretary, and Mr. Wm. T. Hunt, of Newark, is President of the New Jersey State Sewerage Commission.

AN INTERESTING PIECE OF DREDGING is being done with a vacuum dredge by the Empire Dredging Co., of New York, at Savannah, Ga. The Seaboard Air Line Ry. Co. is here extending the slip at their recently completed terminal and also making a rosin storage yard covering over seven acres. The slip is being lengthened 1,500 ft., and the yard is enclosed by railway embankments founded on a soft marsh land. The material is dredged and deposited on this marsh to a depth of 10 ft., and the material is being placed with not over 10 to 15% of water by actual tests made. Mr. W. L. Seddon, Division Engineer, S. A. R. Ry., is in charge of the work.

A WATER-TIGHT DREDGE BUCKET, having no bottom door, has been invented by Mr. Hiram Head, of Helena, Mont. The bucket is pivoted at the lower edge of the back to a rod or shaft carried by brackets on the end of the dipper arm. An upright or block on the upper side of the arm forms a support for the bucket when in normal position, and carries a latch or lock which engages with the top edge of the back of the bucket. The bail for the hoisting rope is also attached close to the back of the bucket. To dump the contents the dipper arm is lowered until it rests upon a post, when the latch is released, and by slacking away on the rope the bucket is allowed to revolve on the bottom shaft. By means of a separate dumping rope, the dipper arm could be held in any desired position by the hoisting rope, and the post thus dispensed with. The device is intended more particularly for dredging in gold-bearing gravel, to prevent any of the gold escaping through leaks at the bottom door of the ordinary form of bucket.

FILLING EMBANKMENTS by dumping from a traveling bridge has recently been carried on by the Chicago, Burlington & Quincy Ry. on some of the new cut-offs which are now being built with the double-tracking and grade improvement of the line in Iowa. The bridge is a through-truss structure, about 120 ft. long, one end resting on rollers and blocking on the bank and the other end resting on a timber tower mounted on rollers on a cribbing built to form a level track. Trains of four-wheel dump cars are run onto the bridge and dumped, and as the bank advances the bridge and traveling tower are moved forward. One of the embankments built in this way is 2,000 ft. long, with a maximum height of 70 ft.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision at Malta, Ill., on the Chicago & Northwestern Ry., on Dec. 29. A freight train had taken the side track to allow the fast passenger train known as the Omaha flyer to pass. In some way, which is not made plain by the press dispatches, the locomotive of the sidetracked train fouled the main track, with the result that the fast running passenger engine collided with it and was thrown from the track with several of the cars behind it. The wreckage took fire and three passenger cars and eight freight cars were consumed. The fatalities were four killed and 18 injured.——On Dec. 27 a coal train ran away on a steep grade on the Scranton Division of the New York, Ontario & Western R. R., near Poyntelle, Pa., and finally gained such speed as to jump the track and plunge down a bank nearly 100 ft. Four men were killed and one was badly injured.

AN ACCIDENT ON THE LIVERPOOL OVERHEAD Electric Railway, at Liverpool, England, on Dec. 24, resulted in the death of eleven persons. The cable dispatches to the newspapers are confused, but as near as it can be ascertained a fuse of one of the motors blew out and fire was communicated to the car, which in turn ignited some piles of creosoted ties stored alongside the track, causing a fierce conflagration. The main facts of the cable dispatches are as follows:

It appears that the burning train entered a tunnel stored with stacks of creosoted railroad sleepers. These were also set on fire, and the tunnel became a blazing furnace. The fire brigade had the greatest difficulty in extinguishing the flames. Fortunately Dingle station, where the accident occurred, is the terminus of the railway, otherwise a terrible disaster would have been recorded. The accident occurred at 6 o'clock in the evening, but owing to the dense volumes of smoke issuing from the tunnel it was 1 o'clock in the morning before an entrance to the tunnel could be effected. Many passengers jumped from the burning train and rushed out of the tunnel, while others were dragged out by their fellow travelers in a half suffocated condition. In spite of the brave attempts made by the officials to enter the tunnel they were soon compelled to abandon this idea. The station buildings were much damaged.

All the killed appear to have been employees of the road. We have commented upon this accident in our editorial columns.

THE DERAILMENT OF A TROLLEY CAR near Lanark, Pa., five miles south of Allentown, Pa., on the Allentown & Coopersburg Electric Ry., on Dec. 24, resulted in the death of six persons and the injury of eleven others. According to the local papers, in going down the steep grade just after passing the top of the Lehigh Mountain the motorman lost control and the car rushed down the mountain at a terrific speed. As the car, in its flight, was swinging around a curve it struck the guy post. Its momentum was so great that the post, which caught the car immediately back of the vestibule, cut through the side, mowing down the passengers. All of those who were killed occupied seats on that side of the car which was raked by the guy post.

AN ELECTRIC BLOCK SYSTEM for street railways, by which the car having the right of way cuts off current from the opposing car's side of the next turnout, has been in use for some time by the Boston & Northern Street Ry. Co. It is not considered altogether satisfactory, however, the cost of maintenance being considerable, but it is reliable if kept in first-class condition and given constant attention. In about four years 8 miles of single-track line were operated in this way, while at the present time about 4 miles are being operated. At busy times in the summer season the cars are run on 15 minutes headway, with 7½ minutes between turnouts. This system was briefly described in our issue of Aug. 29, 1901.

THE FIRST TOKIO ELECTRIC RAILWAY is to be equipped by the General Electric Co., under a contract said to have been secured through the Japanese house of Mitsui & Co., New York. The price stated is $750,000 for the equipment and rails. The latter are to be purchased in England. The car bodies will be made in Japan. The International Pump Co. (Blake Branch) will supply the pumping and condensing plant; the car trucks will be made by the Peckham Mfg. Co., of New York, and the Wainwright heaters will be used. The Morgan Engineering Co., of Alliance, O., is to build a 20-ton electric crane, and the piping is to be furnished by Mann & Taylor, of New York. This tramway is to operate in the principal streets of Tokio, and it is understood that the road is to be open early in 1903. The chief engineer of the Japanese company is Mr. Enyo, who is now in the United States, and has an office in the Havermeyer Building, 26 Cortlandt St., New York. Orders for machine tools, etc., have yet to be placed.

THE OLD HUDSON RIVER TUNNEL CO. is being reorganized, and the prospectus issued by a committee made up of Mr. F. B. Jennings, of New York, and Messrs. John Young and Horace E. Golding, of London, calls for the following financial plan: The new company is to be capitalized at $5,000,000 common and $3,500,000 6% preferred stock, with $7,000,000 5% first mortgage bonds. Of the sum raised $2,200,000 is to be reserved for building a south parallel tunnel, if this should be deemed advisable. No estimate for completing the old tunnel is given. The plans provide for completing the tunnel and its approaches on both sides; tracks for a trolley railway, and equipment for the transfer of passengers and freight.

A DIAMOND DRILL BORING 4,800 ft. deep is described briefly in the publication "South Africa." The hole is located on the Turf Club grounds at Johannesburg, South Africa, and was sunk to disclose the so-called Rand formation. Work was started early in January, 1899, but was stopped on Oct. 1, 1899, in consequence of the approaching war. On May 26, 1901, the rods, which had remained in the hole since the boring was stopped about 20 months before, were raised and on June 14 boring was resumed. The material penetrated was the regular Rand formation and the hole was sunk in 10½ months from the time the drill was put in the ground. This time includes stoppages of all ordinary kinds, but does not include the time that work was discontinued owing to the war. The boring was done by the Chester Diamond Drilling Co., using a drill specially designed for the work by the Sullivan Machinery Co., of Chicago, Ill. The Turf Club hole is the deepest diamond drill boring ever made on the Rand. The Rand-Victoria hole is 2,400 ft. deep and the Bezuidenville hole is 3,251 ft. deep.

THE COST OF MACADAMIZED STREETS at Wyoming, O., has been about 44 cts. per sq. yd., for a total of 109,130 yds., on 28 different streets, with an aggregate length of 53,007 ft. This is an average of $4,767 per mile of roadway 18.53 ft. wide, or 90 cts. per lin. ft. A total of 18,316 cu. yds. of broken stone and screenings were used at an average cost of $1.95 per yd. The average depth of the broken stone, spread loose, was 6 ins. These figures were prepared by Mr. L. W. Mathewson, Village Engineer, Wyoming, O.

PUMPING ILLUMINATING GAS 124 MILES to supply Paris is a French project described in the "Progressive Age" for Dec. 16. The plan has been submitted to the Prefect of the Seine by Messrs. Theo. Cambier and Julien Bernard. The gas would be made at or near the mines, compressed, and transmitted through a pipe line. The prices proposed are 28.7 cts. per 1,000 ft. to the city, 37.5 cts. for private lighting and 34.5 cts. for fuel. Fuller details of the proposition are published in "Le Moniteur de l'Industrie du Gas," of Paris, for Nov. 20, 1901.

DRAWING ROOM; CHIEF ENGINEER'S OFFICE; PITTSBURG & LAKE ERIE R. R., PITTSBURG, PA.

By R. P. Forsberg.*

Among the many elements that go to make up an ideal drawing room, we would undoubtedly find good natural light, clean and commodious quarters, some approved index system, quick blue printing facilities, fireproof vault for storage of drawings, and perchance—*good draftsmen*. In the design of our drawing room these, among other points, were kept in view, and as to how successfully they have been carried out we leave the readers of this article and the engineers and draftsmen who have visited us to determine.

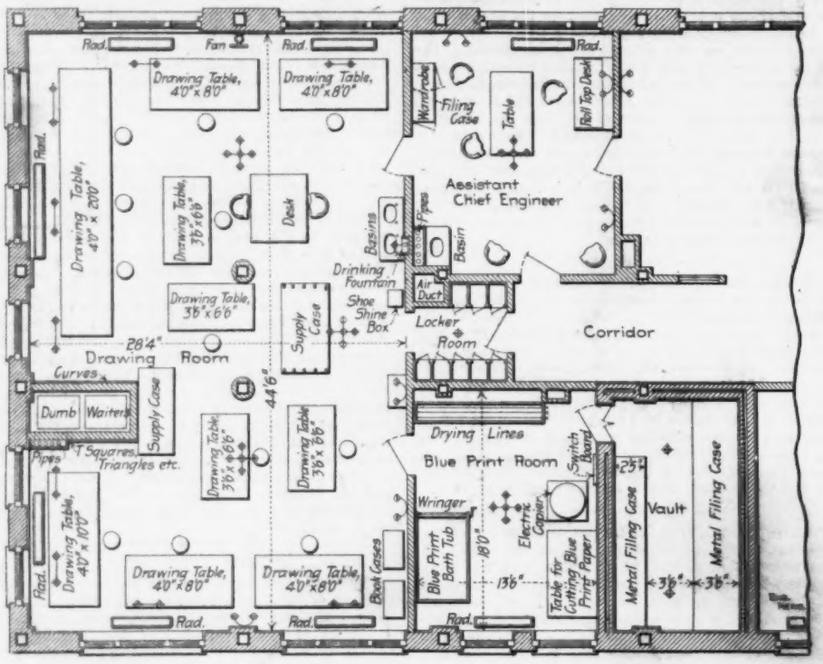


FIG. 1. GENERAL PLAN OF DRAWING ROOM; CHIEF ENGINEER'S OFFICE, PITTSBURG & LAKE ERIE R. R., PITTSBURG, PA.
J. A. Atwood, Chief Engineer; R. P. Forsberg, Chief Draftsman.

GENERAL DESCRIPTION.

The drawing room is located on the fifth floor in the northeast wing of the new Pittsburg & Lake Erie terminal station. It faces the Monongahela River on the east and our terminal yards on the north and west. Its location, therefore, insures the best natural light, and removes the possibility of this light being cut off by future building construction.

One must necessarily be "To the manner born" to fully appreciate what it means when we say that we have in Pittsburg an office practically free from soot, smoke and dust. We have not the allotted space, nor is it our desire in this article, to go into a detailed explanation of our system of ventilation. Briefly stated, however, it is as follows: By means of a forced system of circulation, air, from which practically all extraneous matter has been eliminated by a patent process, is heated to the proper temperature and discharged into the room through openings located 9 ft. above the floor. At the floor level is an outlet of the same area, which, also by means of forced circulation, is drawing the air from the room at a slightly less rate than it is being delivered, keeping thereby a slight excess pressure in the room, which prevents dust or dirt from the outside getting through any crevice or opening that might exist around the window frames. This fresh air is delivered in such quantity as to change the air in the room every 15 minutes. The window sashes are built in, one window in each series being hung on hinges in order that the janitor may get outside to wash them. These windows are kept locked, the janitor having the key. As a result of this system of ventilation the drawings and records are kept clean, and this in Pittsburg is of some significance.

The room is equipped with all modern conveniences in the matter of hot and cold water, distilled drinking water, cooled by ammonia coils to 45°F., and pumped direct from our power house, electric light, electric fans, electric call bells, self-winding clock and individual lockers for coats, hats and umbrellas.

The drawing tables at night are covered with gossamer covers, which, of course, are impervious to any dust originated by the janitor's sweeping, and protect any work that it may be necessary to leave tacked to the table.

The drawing material, field books, unfinished drawings, catalogues, etc., etc., are kept in two cases 5 ft. high, with rolling doors on either side, which stand in the center of the room. On top of one of these cases, which is provided with bronze uprights to prevent the drawings from rolling or falling off, the draftsmen place any drawings which they have taken from the vault during the day for reference, etc., and the custodian of the drawings alone is allowed to return them to their proper place. This insures the drawings being returned to their proper compartment in the vault, and no drawings being left out over night.

We have in our library, among other technical books, a complete bound set of Engineering News from the time of its inception in 1874 to date.

DRAWING TABLES.

The method of construction of the drawing tables is shown in the accompanying working drawings.

The tables are made in four sizes: 3 ft. 6 in. × 6 ft., 4 ft. × 8 ft., 4 ft. × 10 ft., and 4 ft. × 20 ft. All the tables are 3 ins. in thickness. The smaller tables (Fig. 2) have hardwood rectangular edges and are used by the draftsmen engaged in mechanical or architectural work, or any work requiring the use of the T-square. The larger tables (Fig. 3) are used by the draftsmen engaged in map work and have the front edge rounded as shown. These tables are built up of 1½-in. × 3-in. thoroughly seasoned cork pine strips of best quality, entirely free from knots and well glued together. To guard against any possibility of the strips cracking or pulling apart by shrinkage ⅝-in. steel rods are run at intervals through the tables, at right angles to the length, heads concealed, with nut ends at back of table accessible for socket wrench, in order that any opening that may occur by shrinkage can be closed. To insure a true surface 3 × 3-in. T's are screwed with lag screws at intervals on the bottom of the table. The holes in the T's are slotted, in order that the screws can move in the T's in the event of shrinkage.

Each table contains drawers for draftsmen's instruments, and specially constructed drawer for ink bottles, as shown. The tables are slightly inclined by means of a tapered strip on top of the trestles, which can be removed at will, allowing the tables to be placed in a horizontal position.

The trestles supporting the tables (Fig. 2) are built of oak, having the same finish as the furniture in the room.

The extreme thickness of the tables insures perfect stability and will also permit several new surfaces being put on, with the smoothing plane, when thumb tack holes become too numerous.

CARD INDEX SYSTEM.

All drawings pertaining in any way to the main line or branches of the road are indexed by location, as hereinafter explained. The name of the nearest station or depot at which the structure or map is located always appears in the title of the drawing. For example, our standard title for drawings is as follows:

P. & L. E. R. R.
6' 0" CONCRETE ARCH CULVERT.
at Sta. 3365 near
Haselton.
Scale ⅛" = 1' 0" June 23d, 1901.

In the lower left hand corner of the drawing appears the file number, 3067RS17.

In our card index system we have divided the main line and branches into sections, including from one to six stations or depots, dependent upon the number of drawings included in that section. These sections in the card index drawers are defined by salmon-colored guide cards, which

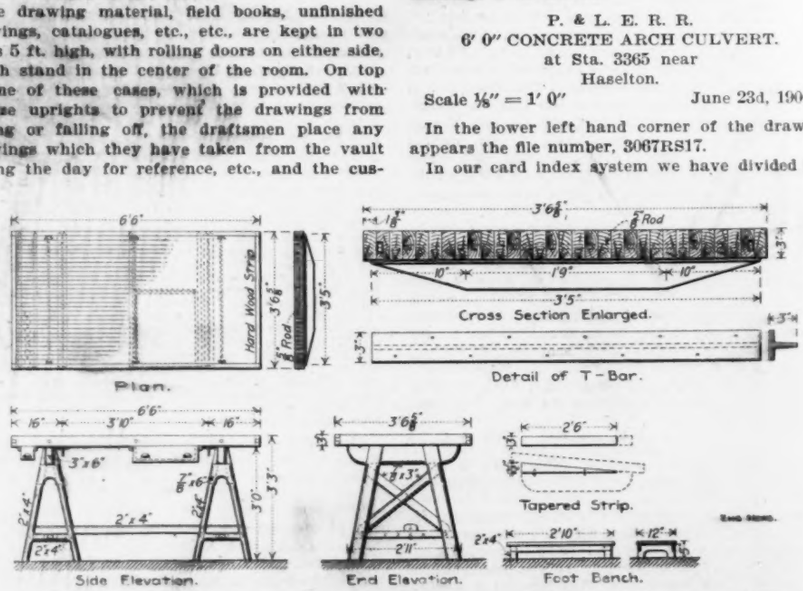


FIG. 2. SMALL DRAWING TABLES FOR CHIEF ENGINEER'S OFFICE, P. & L. E. R. R.

*Chief Draftsman, Chief Engineer's Office, P. & L. E. R. R., Pittsburg, Pa.

xtend the entire width of the drawer, projecting -in. above the index cards. On the ¼-in. pro- ction is printed the stations or depots at the xtreme limits of the section, and on the body of e card the engineering station stake pluses of e limits of the section and the names of the ations or depots included in this section, with eir station stake pluses, as shown in Fig. 4.

The next salmon card, of course, reads "MON- OUR JUNCTION TO STOOPS FERRY," etc. Between these salmon cards are twelve sub-cards of drawings located in the vicinity of that station, usually not over four or five in number.

In the event of some special piece of work which requires a large number of drawings, and consequently would necessitate looking over a large number of index cards in finding a drawing, a set of alphabetical tab-cards are inserted in this subdivision and the index cards are arranged behind them alphabetically. For example, the drawings for our Pittsburg Terminal Station come under the general division "PITTSBURG TO SAW MILL RUN," subdivision "BUILDINGS," therefore in this one subdivision the cards are arranged alphabetically behind alphabetical tab-cards.

The "Miscellaneous" subdivision pertains to drawings having a definite location on the road, which, however, could not be placed under any of the above subdivisions. The "Obsolete" subdivision pertains to drawings which have become obsolete and yet have in themselves sufficient value to warrant their preservation. These obsolete drawings, after being properly indexed, are stored in the basement of our station in strong wooden boxes, and in the event of their being needed are easily accessible.

is made vacant by a drawing being destroyed or relegated to the obsolete case in the basement may be again filled, we have a book which we designate "Ledger," divided into sections corresponding to the compartments in the filing case. In this "Ledger" in the proper section is kept a record of the drawings with their file number. Space is left under each entry for two changes of title, should a drawing occupying the same space and having the same file number become twice obsolete. In another book, which we designate "Journal," each drawing is entered or recorded as soon as completed, without regard to its compartment in the filing case, taking its journal number next to the last one entered.

With the aid of these two books (which it is unnecessary to use except in the event of a card being lost) a correct record is kept of the last file number of each drawing and the contents of each drawer or compartment. These books are kept in the fireproof vault and contain in substance information from which the card index could be readily duplicated were it possible for such an exigency to arise.

This same card index system, with the same divisions of main line and branches, is used in keeping our siding record. The siding record index cards are ruled as shown in Fig. 7. This ruling enables us to make three changes in the length, ownership, etc., etc., of the siding before a new card is required. The same system, with the same divisions of main line and branches, it used for indexing our record books containing survey notes, cross section notes, etc., etc.

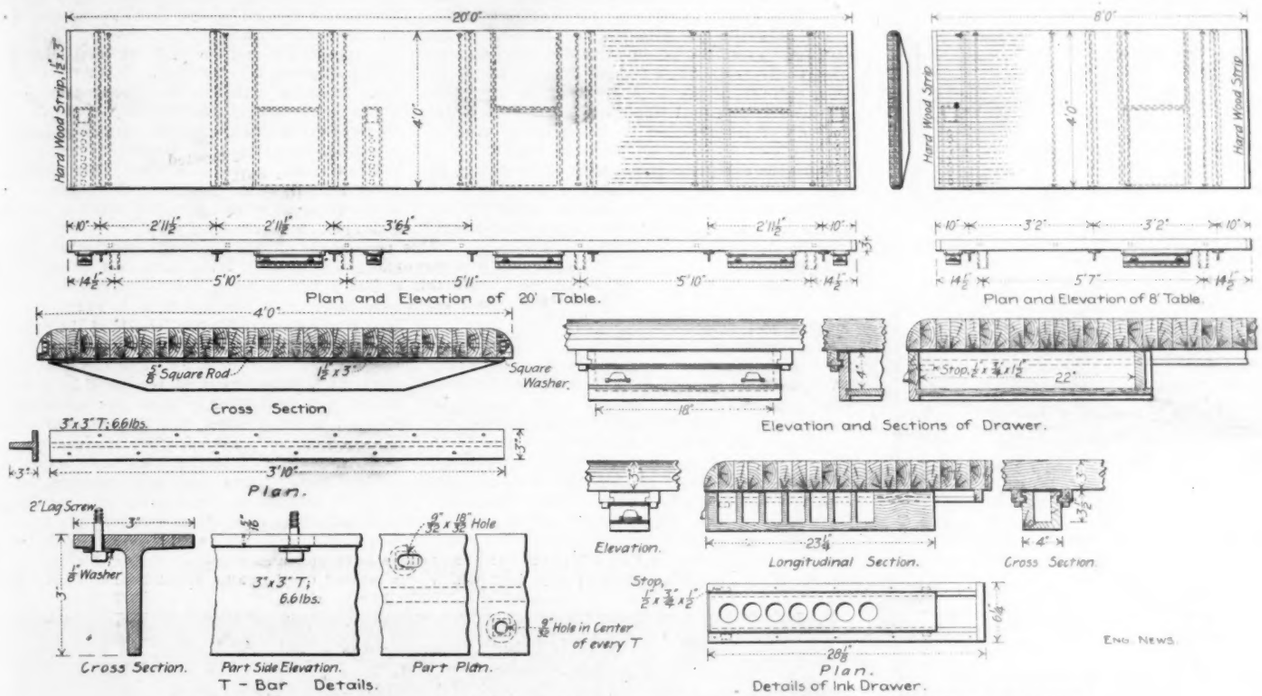


FIG. 3. DETAILS OF LARGE DRAWING TABLES. 4 FT. IN WIDTH AND 8 FT., 10 FT. AND 20 FT. LONG.

divisions, defined by blue cards, known in stock as "thirds." These also have a ¼-in. projection above the index cards, the projection extending one-third the width of the drawer. On this projection is printed the name of the subdivision, and on the body of the card the class of drawings that are indexed under this subdivision; for example, three of these cards are shown in Fig. 5.

This description of the drawings, indexed in each subdivision, is intended both as a guide to the person indexing the drawings and an aid to a person not familiar with the system in locating a drawing. The twelve subdivisions are as follows: "Track Plans," "Right of Way," "Buildings," "Agreements," "Masonry," "Property Plats," "Bridges," "Profiles," "Cross Sections," "Grade Crossings," "Miscellaneous" and "Obsolete."

Between the blue subdivision cards come the buff index cards, which are ruled as shown in Fig. 6.

It can be readily seen that with this system, one can at once turn to the desired subdivision at any station or depot and only read the index

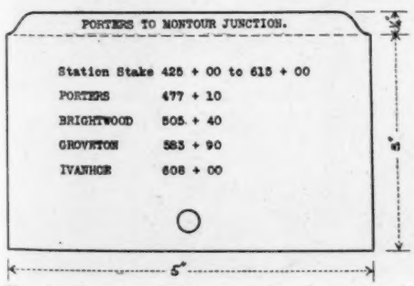


Fig. 4. Sample of Salmon Guide Card; Showing Section of Road Covered.

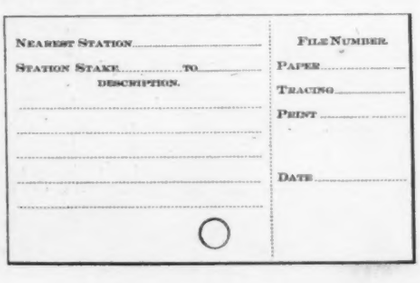


Fig. 6. Sample of Index Cards.

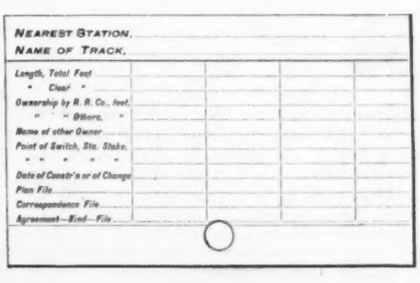


Fig. 7. Sample of Siding Record Index Card.

Standard drawings, which of course have no definite location on the road, and miscellaneous drawings having no location, are indexed alphabetically behind alphabetical tab-cards in special drawers marked "Standards" and "Miscellaneous" respectively. All catalogues pertaining in any way to engineering supplies or structures are also indexed alphabetically in a separate drawer.

In order that the space in the filing case which

STANDARD SIZE DRAWINGS.

All drawings, except continuous maps, profiles,

rail charts, cross sections, etc., etc., are made on standard sizes, which are as follows:

Border.	Outside.	Border.	Outside.
8 × 13 ins.	10 × 15 ins.	10 × 22 ins.	12 × 24 ins.
8 × 18 "	10 × 20 "	10 × 28 "	12 × 30 "
8 × 24 "	10 × 26 "	10 × 33 "	12 × 35 "
8 × 30 "	10 × 32 "	15½ × 24 "	17½ × 26 "
8 × 34 "	10 × 36 "	15½ × 30 "	17½ × 32 "
10 × 15½"	12 × 17½"	15½ × 34 "	17½ × 36 "

Tracings from continuous maps and profiles are made on sheets of varying widths, 70 ins. long, from which continuous rolls of blue prints are

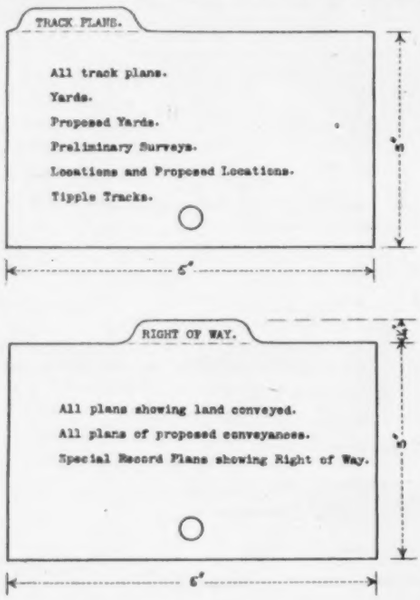


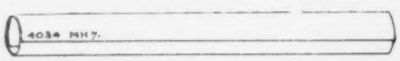
Fig. 5. Samples of Blue Guide Cards, Showing Classification of Drawings and Records.

made. Two sets of tracings 17 ins. × 70 ins. are made from our continuous record maps of main line and branches. One set contains all topography to date, including exterior or governing right of way lines only, where there have been several purchases. The other contains only information pertaining to company property or right of way, showing each individual purchase, with number and abstract from deed.

FILING CASES.

All drawings are filed in a fireproof vault, equipped with japanned steel filing cases, as shown in Fig. 9. All standard size drawings, including the right of way tracings and tracings from continuous or roll maps, are laid flat in drawers, and only the continuous or roll maps are put on the shelves.

These have their file number on the outside at either end, as shown.



The location of the compartments in shelves and the drawers is determined by the intersection of the horizontal and vertical letters on the filing cases. The drawings in the compartments or drawers each have a separate file number and are, of course, arranged numerically. For example, in the file number "3067RS17" 3067 represents the "Journal" number, which it is unnecessary to use in locating a drawing, RS the compartment in which the drawing is located, determined by the intersection of these two letters, and 17 its numerical position in the compartment or drawer.

The drawers in the filing case are designed to fit our standard size drawings and are 2¾ ins. deep in the clear. Each drawer has a metal covering at the back 6 ins. wide, extending the entire width of the drawer, which prevents the tracings from curling up at the end and becoming mutilated.

In the bottom of each drawer, in the left hand corner, is a metal strip which lays flat and works on a hinge that is attached to the back of the drawer. This is used to raise the tracings and insert the hand when looking for the file number, thereby saving to a great extent the wear on the tracings that would otherwise occur. The method of construction of one of these drawers having two divisions is shown in Fig. 8.

With the exception of the right of way tracings, 100 tracings are put in each drawer or each division in the drawer. Dependent upon the size of the tracings, some drawers have two and some five divisions, which hold 100 tracings each.

At the end of one of the steel filing cases, built in the case, are 15 individual safety deposit boxes with lock and key for the private use of the engineers and draftsmen.

The ladders which are used to reach the top shelves in the vault, run on an overhead track and can be set up flush with the sides of the filing case when not in use.

The vault is provided with the same system of ventilation that is in use in the other rooms, with the exception of the duct for exhaust air being omitted. As a result of this, the fresh air that comes in the vault is drawn through the vault door opening into the blue print room and out through the exhaust duct in the blue print room. This maintains a steady flow of air outward from the vault and tends to prevent any dust which might be originated in the blue print room from entering.

BLUE PRINT ROOM.

The blue print room, which immediately adjoins the drawing room, is equipped with an "Electric Copier," as shown in Fig. 10, with which all blue prints are taken.

The "Electric Copier" consists of a cylindrical plate-glass frame ¼-in. thick, mounted on a revolving iron stand. The plate-glass is in two sections, each having a surface area of 42 ins. × 72 ins. The glass is covered with two movable canvas jackets or coverings, which are attached to a vertical wooden strip that holds in position the two sections of plate-glass. Directly opposite this is a similar wooden strip, to which is attached the spring fastenings that hold the jackets in close contact with the glass while the prints are being taken. The vertical wooden strip at the back of the frame is provided with springs for holding the tracing and blue print paper in position while the copier is being loaded, and are especially useful when a number of small prints are being taken at the same time.

A special 110-volt enclosed arc lamp, taking 10 or 12 amperes, and having an adjustable resistance in series with the arc, mounted on a slate switchboard, is suspended directly over the copier by means of a small wire cable, which passes over a pulley wheel that is supported by a steel bracket bolted to the side wall. This small wire cable runs from the pulley on the bracket to an automatic gear or escapement located on the slate switchboard on the side wall.

By means of this automatic gear, which simply consists of a small drum connected directly to an ordinary "grandfather clock" escapement with an adjustable pendulum, the lamp is gradually lowered throughout the entire length of the cylinder.

By this means a uniform distribution of light is given the entire tracing. The speed at which the lamp is lowered can be regulated by the pendulum and is dependent upon the sensitiveness of the blue print paper and the transparency of the tracing. In actual practice the pendulum is rarely adjusted. With the extra rapid paper that we use small prints from new tracings can be made in 45 seconds, the longest tracings, 70 ins. in length, requiring three minutes.

In addition to the regular double-pole switch we have also an automatic cut-out switch, which is located on the same switchboard. This switch is operated by a counterweight, which is connected to the lamp by a wire cable and comes in contact with a spring to which is attached a small brass chain connected to the automatic cut-out switch. This counterweight comes in contact with the spring just before the lamp reaches the bottom of the copier, thereby opening the switch and cutting off the current. The spring also prevents any jar that the lamp might otherwise receive in being brought to a stop.

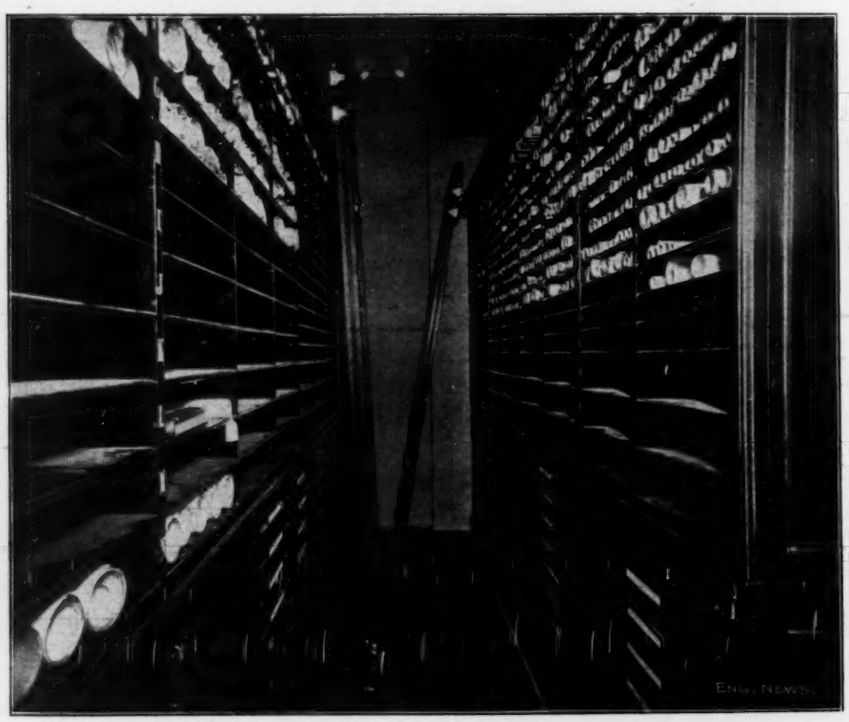


FIG. 9. METAL FILING CASES IN FIREPROOF VAULT.

With the aid of this automatic cut-out switch the operator need give no attention to his print from the time it is put in the copier until it is ready for the bath tub. After removing his print the operator, by simply throwing the drum out of gear, winds the lamp to the top of the copier, where it is held in position by a small lug that nts in between two teeth on the escapement, and the copier is again ready for work. A shadow, of course, is thrown on either side of the lamp by the rods or standards of the lamp. These shadows, however, have no effect on the prints, the vertical wooden strips, heretofore described, always being placed opposite the lamp rods.

The advantages of this style of printing over the old sun process are "legion." Among them may be noted: Uniform color of prints; rainy or cloudy days do not affect it; perfect contact between tracing and paper; economy of space in blue print room, and apparatus always ready for use.

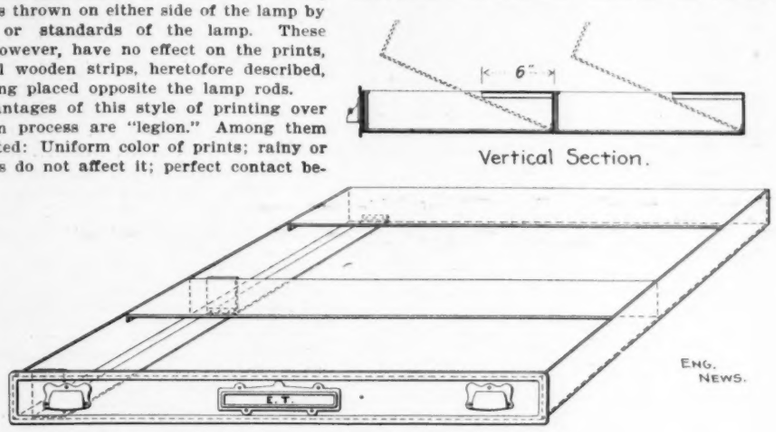


FIG. 8. DRAWER USED FOR FILING DRAWINGS.

A table, 3 ft. 9 ins. × 6 ft. 9 ins., for cutting blue print paper stands next to the copier. This table is provided with a set of drawers for holding supplies.

The bath tub, 6 ins. deep, 3 ft. 6 ins. wide and 6 ft. 3 ins. long in the clear, is provided with hot and cold water and is lined with sheet lead. The stand supporting the tub is also provided with a set of drawers for supplies. A wringer with hard rubber rolls 39 ins. long in the clear is located on the end of the tub. With the aid of this wringer the prints leave the bath tub practically dry, having to remain only a short time on the drying lines before they are ready for use. It also reduces the length of drying lines to a minimum. The drying lines consist of copper wires supported in an oak frame 6 ft. 6 ins. above the floor. On the wires are strung wooden clothes-pins for holding the prints. The windows in the blue print room are glazed with ruby glass, removing thereby any danger of paper being light-struck by exposure.

The general layout of the drawing room, together with all details, was carried out in accordance with the ideas of Mr. J. A. Atwood, Chief Engineer, and Mr. A. R. Raymer, Asst. Chief Engineer.

A WESTINGHOUSE PATENT ON ENGINEER'S BRAKE VALVES SUSTAINED.

On Dec. 21 a decision was rendered by Judge Coxe, in the United States Circuit Court for the Northern District of New York, in a suit of the Westinghouse Air Brake Co. against the New York Air Brake Co. for infringement of a patent on engineers' brake-valves. The patent sustained is No. 401,916, issued to George Westinghouse and Frank Moore April 23, 1889, and covered the automatic closing of the valve after making a service application. The following extract from the Judge's decision makes clear the effect of the invention in the operation of brakes on long trains:

The patent in suit relates to an improvement designed to remedy certain defects which were developed when a long train was being stopped at stations or slowed down without being brought to a standstill. Prior to the invention in question the engineer in making a service stop or slowing down opened his brake-valve a little, permitting the escape of a small quantity of air, and then slowly closed the valve. The closing, being regulated by hand, was not uniform, and sudden closing was frequently followed by serious consequences, resulting in damage, inconvenience and delay, and a possible loss of life and limb. The reason that the hand-closed valve was imperfect and dangerous may be briefly stated as follows:

In order to set the brakes a reduction of pressure in the train pipe is necessary. The air is released by the valve on the locomotive and the brakes at the forward end of the train are the first to feel the effect of the opening of the valve. In the meantime the compressed air in the rear portions of the train pipe, which on freight trains is often over a third of a mile in length, is moving towards the vent with increasing momentum. If the vent be suddenly closed the air is piled up, so to speak, at the forward end of the pipe, thus exerting sufficient pressure to release the brakes on the cars at the front end of the train. The forward surging of the air operates to set the rear brakes and release the front brakes, thus causing the train to be pulled apart.

The defect was a serious one; everyone recognized it and its cause, but for a long period no one found a satisfactory cure. What was needed was an engineer's valve which would secure a uniform reduction of pressure throughout the longest train pipe, so that the brakes, on all the cars alike, would be released at the same time.

After several years of experiments such a valve was secured by the efforts of Westinghouse & Moore. They succeeded in producing a slow closing of the vent port, which closing is accomplished automatically beyond the volition and control of the engineer. His work is done when he opens and closes the cock which reduces the pressure in the chamber above a piston connected by a stem to the vent valve, which is raised from its seat by the unreduced pressure below the piston. The opening of the vent port gradually reduces the pressure below the piston until it is less than the pressure above and thus the valve will close, slowly at first, but more and more slowly as the pressure above and below is equalized, until the final resting of the valve on its seat is almost imperceptible. All this is accomplished by the patented device, which, though scarcely larger than an ordinary teapot, is a complicated labyrinth of valves, ports, chambers and passages which it is difficult to describe except diagrammatically. It is enough to say for present purposes that it accomplished the desired result. In the language of the specification:

The slow and gradual downward movement of the piston in closing the discharge-valve admits of a sufficient time for the equalization of pressure throughout the entire length of the brake-pipe and thereby insures a substantially uniform application of the brakes on all the cars of a long train.

The infringing valve of the New York Co. was made under patent No. 504,290, issued to Vaughn & McKee, Aug. 29, 1893. The Judge analyzes this valve, and finds that while the parts are in appearance dissimilar they are, when analyzed, found to contain the essence of the Westinghouse invention, and to infringe Claims 4 and 8 of the Westinghouse patent.

Fig. 10. Loading Electric Blue Printing Apparatus.

SPECIFICATIONS FOR GARBAGE FURNACE AT THE NAVY YARD, LEAGUE ISLAND, PA.

The United States Government built some of the first garbage furnaces in this country, twenty years or so ago, and has been building them at military posts and elsewhere ever since. As work of this sort has seldom been entrusted to municipal engineers, but is likely to be in the future, we reprint a portion of the specifications for a furnace to be built at the Navy Yard, League Island, Pa., as issued in October last by Mordecai T. Endicott, Chief of the Bureau of Yards and Docks, Navy Department, Washington, D. C.:

30. With the minimum of attention and fuel, the incinerating plant, as a whole, shall be capable of consuming garbage, rubbish, and all kinds of animal, vegetable, and other waste matter, without creating a nuisance by fumes, odors or smoke. The size of the plant and its capacity shall be made as large as the funds available will permit, it being the intention of the government, in so far as possible, to operate the plant only during the eight hours of each working day. Should it be necessary, however, to operate the plant continuously 24 hours per day, using the particular apparatus, and the system of incineration entailed thereby, on which the proposal submitted is based, bidders shall state such fact in their proposal. Should fuel be required to assist combustion, the furnace shall preferably be designed for the use of wood.

31. Each proposal shall state the number of square feet of grate area, the number of pounds of garbage or refuse of various kinds guaranteed to be incinerated per square foot of grate area per hour for a continuous run of eight hours, the number of pounds of fuel to be used per square foot of grate area per hour, the number of men necessary for the operation of the plant. The result of a comparison of the tests made after completion of the plant, with the guaranteed performance, will be taken in part as the measure by which the contract has been fulfilled, and the government reserves the right to reject the plant should the test fall below the guaranteed results; and should it elect to accept the plant with any such deficiencies in performance, then there shall be such decrease in the contract price, because of such deficiencies, as shall be recommended by a board of naval officers, as approved by the Bureau of Yards and Docks.

32. On account of the small size of the plant, it is not desired that attention be given to the utilization of any of the heat generated, or the ashes and other material remaining in the furnace after incineration. It is intended that this material will be removed and used as filling, etc.

33. Each proposal shall state whether any particular treatment of garbage, etc., is necessary before putting it in the furnace, and provision must be made for same. If water and sewer connections are necessary, their required location should be shown, and, if within the building, the same shall be included in the contract. At present there are no water mains or sewers in this part of yard, but they will be extended to the crematory site in the near future by the government.

34. The approach, if necessary, leading from the ground, to carry material to be incinerated, by carts, to the top of furnace, will be furnished by the government up to the building line.

35. Foundations.—The foundations of building, furnaces and stack shall be of brick or concrete, supported in such substantial manner as shall be satisfactory to the officer in charge. The permanent foundations within the yard are usually built on piles, but the contractor shall visit the yard, previous to submitting his bid, and familiarize himself with the conditions and make a definite proposition in this regard, based upon his investigations. All excavation, leveling off and back filling shall be included as a portion of the work to be done under the contract. The ground shall be graded to within 5 ft. of the building on all sides as required.

36. Building.—The building shall, preferably, be of steel frame, with brick curtain walls or galvanized steel covering, with suitable windows and wood doors, with wood frames. The steel columns shall be anchored to the foundations with two bolts each, of not less than 1¼ ins. diameter. The roof shall be about "one-fourth" pitch and will have steel purlins and wind bracing. The roof trusses shall have knee braces. The thickness of metal used in any part shall in no case be less than ¼-in. All field connections must be riveted. The roof shall be designed for a total load of 40 lbs. per sq. ft. Floor beams, if used for platform floor inside of building, shall have an extreme fiber strain not exceeding 16,000 lbs. per sq. in. In determining the size of the building upon which their proposals are based, bidders shall provide for a clearance of at least 4 ft. behind and at the sides of the furnace, and for sufficient room in front of same to use fire tools, and for such easy access as may be necessary.

37. The corrugated steel, if used, shall be of No. 22 gage, laid with a side lap of 1½ corrugations and an end lap of 6 ins. The siding, if used, shall have a side lap of one full corrugation and an end lap of 4 ins. The corrugated steel shall be attached to purlins and girts by ¾-in. galvanized steel clips, 20 gage, riveted with tinned rivets. Clips shall be spaced about 12 ins., c. to c., and sheets shall be riveted between clips and along edges with tinned rivets as required. There shall be a suitable ridge roll.

38. All steel shall be given a coat of red-lead paint at the shops, after cleaning, there being 25 lbs. of pure red lead to each gallon of pure linseed oil. After erection all steel shall be given two heavy coats of white-lead paint in linseed oil, in addition to a priming coat of above quality of red-lead linseed-oil paint, applied after erection; all galvanized steel shall be given two heavy coats of the same quality of paint. Windows and doors, after priming, shall be given three coats of the same kind of paint; all painting to be in such colors as shall be directed by the officer in charge. All other material shall be painted in manner as may be required for its proper preservation and appearance.

39. The ground floor shall be of Portland cement concrete, 7 ins. thick, exclusive of a finished surface of 1 in. of cement mortar composed of one part Portland cement and one part sand. This floor shall be set in place on top of the gravel fill specified under paragraph 45.

40. Furnace.—The furnace or furnaces shall be of approved design and construction, fitted with all the necessary appliances, dampers, doors, openings for draft regulation, etc., and fire tools. The interior, and wherever necessary, shall be laid with fire brick. It must be so arranged that material can easily be fed into it with as little labor as possible, and the ashes, etc., removed. The furnace will be properly braced and tied together by heavy rods, buck stays and binders, and all work shall be of the best of its kind.

41. Stack.—The stack shall be of brick or steel, self-supporting, strongly anchored, and not less than 75 ft. in height; to be lined with fire brick for about one-fifth of its height. It shall be figured to withstand a wind pressure of 40 lbs. per sq. ft. With a steel stack the minimum thickness of metal will be 3-16-in. Previous to painting, the surface of the metal shall be freed from all rust and cleansed from all dirt and grease. Previous to erection of the stack in place, it shall receive one good heavy coat of paint, both inside and outside, well worked into all joints. After erection a second coat of paint shall be applied to the exterior of the stack. The paint shall be of a kind especially adapted to the purpose; it shall be of an elastic, tenacious, impervious character, and be capable of continued resistance to temperatures ranging from zero to 600° F. To be equal to "Protectus" or "Bitumastic," as shall previously be approved by the officer in charge. If of brick, the stack shall be of hard red brick or hollow radial brick, laid in cement mortar. Stack shall be provided with clean-out door, steel or wrought-iron ladder, etc., and if of brick, with cast-iron cap. The dimensions, sizes and detail of the several parts to be subject to the approval of the officer in charge.

Paragraph 45, to which reference is made in Sec. 39, calls for 12 ins. of clean gravel, puddled and tamped, beneath the concrete floor. Concrete, in general, must be of Portland cement, 1:3:6, all by measure, the cement to be packed.

The bids received under these specifications were given in our issue of Oct. 31, on p. 149 of the supplement. The contract was subsequently awarded to Mr. Benj. Boulger, 39 Cortlandt St., New York city. The furnace will be of the Morse-Boulger type, and will cost about $7,000.

AN ADJUSTED TONNAGE METHOD OF LOCOMOTIVE RATING.

The practice of giving freight locomotives train loads which will represent approximately the hauling capacity of the engines is now in very general use, replacing the old system of making up trains of a specified number of cars, regardless of their capacity. Various methods are used for making ratings for different classes of locomotives, working under different conditions of grade, etc., and under different atmospheric conditions. At the December meeting of the Western Railway Club, in Chicago, Mr. D. F. Crawford, Superintendent of Motive Power of the Pennsylvania Lines at Fort Wayne, Ind., read a paper describing a system used on his road, and from this paper we take the following extracts:

The method is, in brief, the introduction of a car-allowance factor for the purpose of making an adjustment for empty and loaded cars. This factor is determined by dividing the difference in the maximum weight of a train of loaded cars and a train of empty cars, that can be hauled over the division for which the ratings are to be made, by the difference in the number of cars. The figure thus obtained is added to the weight of each car, whether loaded or empty. With this adjustment added, it will be found that the adjusted tonnage of the train will be the same whether it consists of loaded or empty cars and that the work done, or drawbar pull, will be the same in each case. Fast freights and stock trains have separate rating sheets.

In determining the locomotive ratings and car allowance factors, a number of tests have been made; in fact, practically all the ratings have been verified, either by dynamometer tests or by speed records over each division. Tests were made of trains of both loaded and empty cars, so that the car allowance, as well as the locomotive rating, could be checked.

Some of the formulae used for ascertaining train resistance at various speeds are based on the indicated horse-power, or drawbar pull calculated from it. Comparisons of indicated and dynamometer drawbar pull show that the former is too high, the losses in the locomotive apparently increasing more rapidly than the speed.

On the road referred to, the rating of locomotives by the method given has proved very satisfactory. Trains made up entirely of loaded or empty cars, or of both loaded and empty cars, making approximately the same time between termini and under similar weather and engine conditions burning practically the same amount of coal, show that the locomotive rating is uniform notwithstanding the variations in the weight and number of cars. Of course, the adjustment figure, or paper tonnage, as it has been called, enters into the rating figures only.

The "A" rating represents the hauling capacity of locomotives under favorable conditions, and must always be used unless instructions to the contrary are issued by the division superintendent, who names the rating to be used during a given period. In practice the ratings are used approximately as follows: Above 40°F., rating A; 40° to 20°, rating B; 20° to 10°, rating C; and below 10°, rating D. Ratings below "D" are not given, as usually when weather conditions are so severe as to interfere with hauling the "D" rating, trains are run under special orders. The lower ratings are also used for convenience in loading engines in the direction of light traffic, and sometimes on a single line where it is desirable to cover the distance between certain points at a higher rate of speed than permitted by the "A" rating.

While no fixed method is used for decreasing the ratings of the locomotives about ready to go to shop for general overhauling, the rating for such an engine is reduced by bulletin notice, usually to the next rating below those prevailing.

STANDARD DIMENSIONS FOR BOX CARS.

For some years a movement has been in progress among railway officers and the railway clubs in favor of the adoption of standard dimensions for box cars, in the interests of the railway motive power and traffic departments. The question has been discussed at some length in Engineering News (1896, I., 163, 169), and definite action upon it has at last been taken. At the St. Louis meeting of the American Railway Association, in October last, a resolution was adopted as follows:

The dimensions of the standard box car to be 36 ft. in length, 8 ft. 6 ins. in width, and 8 ft. in height, all inside dimensions. Cross section, 68 sq. ft.; capacity, 2,448 cu. ft. The side door opening to be 6 ft. in width.

At the same time a resolution was passed requesting the Master Car Builders' Association to consider and adopt the required external dimensions of the standard box car, based upon the interior dimensions prescribed by the American Railway Association. A committee of the Master Car Builders' Association was appointed, and has made a preliminary report, which we give below, substantially in full.

After a careful consideration of the limiting dimensions of the important railway clearances, the present established height of loading platforms, the various methods of car-body construction and such others matters as seemed to have a bearing on the subject, the committee proposes the following dimensions for exterior dimensions for this class of cars:

For a box car set on the trucks used as standard, where the height from top of rail to top of floor is 4 ft.; Height, top of rail to upper edge of eaves, 12 ft. 6¾ ins. The following details were used to determine the above elevation:

Top of rail to upper face of floor	4 ft. 0	ins.
Upper face of floor to under edge of carline	8 ft. 0	"
Width of carline at end where secured to plate	3 13/16	"
Thickness of rafter to which metallic roof is applied	1⅜	"
Thickness of purlin to which roof boards are secured	1⅛	"
Thickness of roof boards	12/16	in.
Total	12 ft. 7⅛	ins.
Less pitch of roof from inside edge of plate to outside edge of eaves	⅜	in.
Total	12 ft. 6¾	ins.

Width at eaves at above height (maximum), 9 ft. 7⅝ ins. The following details were used to determine the above dimensions:

Width between lining	8 ft. 6	ins.
Thickness of lining	1⅝	"
Thickness of siding	1⅝	"
Thickness of posts and braces	6	"
Air space between fascia boards	1	"
Thickness of fascia boards	1⅝	"
Projection on each side for roof, ¾-in.	1½	"
Total	9 ft. 7⅜	"

The committee believes that with the above allowances no difficulty whatever will be encountered in framing a car with a metallic roof as is ordinarily applied. Where a double board roof is applied with the ordinary construction, this width can be reduced from ⅝-in. to ¾-in. by using the usual 1¾-in. rabbeted fascia board, allowing the roof to project from ¾-in. to 1 in. over the fascia boards.

The committee recommends as a minimum distance from top of rail to bottom edge of outside sill not less than 1 ft. 6 ins. This limit is recommended for the reason that on many roads there are girder bridges and viaducts which necessitate a limit at this point.

For a box car set on low trucks where the height from top of rail to top of floor is 3 ft. 6 ins.: Height, top of rail to upper edge of eaves, 12 ft. ¾-in.; width at eaves, at above height (maximum), 9 ft. 10 ins. In determining the above elevation, the same details were used as in the case of the car set on trucks used as standard, except in the dimension given for height from top of rail to upper face of floor.

The committee has not made any recommendations as to longitudinal dimensions, but it is of the opinion that the strongest end possible should be used in the construction of the car, regardless of the exterior longitudinal dimensions. It, however, recommends the dimensions for cross-section and elevation at the eaves submitted above for consideration, and has given sizes for the different parts used, believing that they are ample for the framing of a car to meet the inside dimensions adopted by the American Railway Association.

C. A. Schroyer (Chairman), G. W. Rhodes, W. P. Appleyard, J. N. Barr, Joseph Buker, Committee.

BOOK REVIEWS.

MOSQUITOES.—How they live; how they carry disease; how they are classified; how they may be destroyed. By L. O. Howard, Ph.D., Department of Agriculture, Washington, D.C. New York: McClure, Phillips & Co. 1901. Cloth; 5¾ × 8 ins.; pp. 241; profusely illustrated. $1.50.

With this pest of the human race as a somewhat unpromising subject, the author has produced an interesting as well as a useful book. It is only within the last few years that scientists have discovered that in addition to being an intolerable nuisance, mosquitoes are responsible for the transmission of malarial germs; and that special members of the family can and do transmit yellow fever, and the terrible disease known as elephantiasis. From this new point of view the extermination of mosquitoes—wherever possible, becomes a necessity; and to this end we must first be enabled to detect the dangerous among the comparatively harmless types, study their habits and know their life. With this knowledge secured, we may then more intelligently formulate means for their destruction. It is this information which Mr. Howard scatters abroad for the better health and comfort of his fellow men.

Many old theories and beliefs are rudely exploded. We find that mosquitoes hibernate in the adult state and may live a year; and that the larvæ imbedded in solid ice will come to life again under proper conditions. It is the females which do the singing and feed on human blood; the males are quiet and are content with a vegetable diet. Mr. Mayer found that the great plumed antennæ of the male vibrate when the song of the female mosquito strikes them; and by turning his head until both antennæ are alike affected the male can exactly locate the songstress and he flies towards her. The author quotes a correspondent who was experimenting in harmonic telegraphy and who was amazed to find that when a musical note of a certain pitch was produced by electrical means, all the mosquitoes in the room would rush upon the apparatus.

He utilized his discovery by covering a large surface with fly-paper and thus captured all the mosquitoes in the neighborhood. Mr. Howard says that his correspondent failed to note whether only males were thus secured; but the experiment is suggestive.

It is only the genus Anopheles, among mosquitoes that will develop and carry the germ of malaria, as has been conclusively proven by the investigations conducted on the Roman Compagna by Drs. Sambon and Low, in 1900; and this dangerous fellow is easily distinguished from the more common and comparatively harmless Culex—when you know how. The tropical yellow fever mosquito is the Stegomyia fasciata, which has been especially studied by the medical staff of the American Army of occupation in Cuba; and the successful efforts of these men to exterminate this type have most materially reduced the frequency of yellow fever cases in Havana. To rid any locality of mosquito larvæ the author recommends the use of kerosene in breeding pools, applied every 12 to 15 days in difficult cases. And this same remedy must be applied not only to pools proper, but to water-barrels, fire-buckets, post-holes, or any receptacle for stagnant water. In Cuba, the rule is one ounce of kerosene to each 15 sq. ft. of water surface twice in a month. Mr. Howard has no faith in tar, creosote oils or permanganate of potash, all of which have been suggested. Drainage and the filling of low places are almost necessary adjuncts to the successful work of extermination. Screens in houses are the best remedy against the adult mosquitoes; and the liberation of chlorine gas—obtained from the combination of crude sulphuric acid with chloride of lime, will kill mosquitoes in a room, which must be vacated, however, while the fumigation goes on. Mr. Howard concludes with a chapter on "How to Collect and Preserve Mosquitoes," which will hardly be appreciated by anyone except the most enthusiastic student of mosquito lore. The most useful portion of the book is that which treats of the practical means adopted for exterminating mosquitoes in various localities, and this part should win many purchasers for the book among engineers.

A WATER POLLUTION suit has been decided against the city of Birmingham, Ala., and the city forever enjoined from discharging sewage into Valley Creek, at or near the lands of a certain riparian owner. The decision was by the State Supreme Court, and sustains a lower court. The case appears to have been selected out of several as a test case. A county sewerage commission is working on plans for a joint trunk sewer and disposal works for Birmingham and vicinity. Mr. Julian Kendrick, City Engineer of Birmingham, is engineer to the commission.

A BUREAU OF RURAL ENGINEERING, under the U. S. Department of Agriculture, is suggested in a recent report by Dr. A. C. True, Director of the Office of Experiment Stations, Washington, D. C. This bureau would include the irrigation investigations carried on for several years under the direct charge of Mr. Elwood Mead, M. Am. Soc. C. E. It would also include a consideration of problems connected with the laying out of farms and other rural estates, parks and the like, drainage, water supply, means to prevent land erosion, and matters relating to farm buildings, implements and machinery.

THE TRANS-ALASKAN RY. CO., which, with another company almost identical in name, is asking Congressional help in the form of land grants, is telling wonderful tales of the mineral wealth which its construction would make available. The proposed line is 850 miles long; starts at Cook's Inlet, crosses the Yukon at Koserfski, and then strikes the end of Cape Prince of Wales, on Bering Straits. There is an indefinite prolongation across the Strait into Eastern Siberia, with a future connection with the Russian-Siberian railways. The prospectus talks of copper in 60-lb. chunks, oil in pools on the surface, a delightful climate and fertile soil in the belt of coast warmed by the Japanese current, etc.

EAST INDIAN IRRIGATION, according to the last annual review of irrigation, issued Sept. 30, 1901, shows the following general results: From this report it appears that 22 of the large productive works yield a net revenue of 9.52% on the capital outlay, and 13 others yield only 0.79%, reducing the average return to 7%. The total area of crops irrigated or protected amounts to 18,500,000 acres, an increase of 750,000 acres over the previous year. A commission is being appointed, with Sir Colin Scott-Moncrieff as chairman, to lay down rules for the connection, encouragement and control of irrigation works in India. The report mentioned says that the total surplus revenue earned since the Indian government undertook the development of irrigation works, amounts to nearly $50,000,000.

COAL IN THE PHILIPPINES is reported upon in detail by Lieut. C. H. Burritt, in charge of the Mining Bureau at Manila. Coal was reported in the island of Cebu in 1827; but no mining was attempted until 1846; and the first coal-mining concession was granted in 1853. Analyses are given of coal from a number of localities, from veins ranging from 4 to 15 ft. in thickness. The coal is a lignite, containing from 41 to 85% carbon; from 3 to 11% ashes, and 23 to 48% volatile matter. The report compares this coal with Japanese coal and the lignite coals of Wyoming and other places; and Lieut. Burritt sees no reason why this Philippine coal should not compete with Japanese and Australian products in the Far East, for steam making. He thinks it undoubtedly will so compete when the mines are developed and made to produce a better class of coal than the surface analyses show.

THE INCOME AND EXPENDITURES of the railways of the United States for the year ending June 30, 1901, is summarized by the statistician of the Interstate Commerce Commission in a preliminary report recently issued. The figures include returns from railways operating 192,193 miles of line and are concisely summarized as follows:

The passenger earnings of these railways were $425,909,210, and the freight earnings $1,114,740,770. The total gross earnings were $1,573,164,205, or $8,211 per mile of line. The gross earnings as shown in the final report for 1900 were $1,487,044,814. As the operating expenses amounted to $1,023,156,281, or $5,323 per mile of line, the net earnings of the roads contained in this advance statement were $555,007,924, or $35,577,218 in excess of their earnings during the fiscal year 1900. The total income of these roads, including $65,271,244 received from investments and other sources, was $620,279,163. Deductions from income, not including dividends, were $421,625,796. Included in this amount are interest on bonds, rents for leased lines, betterments charged to income, taxes ($47,041,214) and miscellaneous charges. The amount of dividends declared during the year was $121,108,637. The amount of dividends shown for the same roads in 1900 was $108,210,052, or nearly $13,000,000 less. The surplus from operations was $77,544,735. In the complete report for the preceding year ending June 30, 1900, the surplus was found to be $87,657,933.

CHARCOAL BRIQUETTES FROM WOOD WASTE IN SWEDEN.

The manufacture and carbonization of briquettes, made from waste lumber, is being successfully carried out at the Skonvik Sawmills, in Sweden. From a report upon the results secured, made by Mr. Gustaf von Heidenstam, and abstracted in "The Engineer," of London, the following details are noted:

The wood should be thoroughly dry; though the presence of about 50% of water in the waste lumber requires the consumption of a large amount of fuel for this drying process as ordinarily carbonized. As the waste from lumber and sawmills varies greatly in form and size, it is found more convenient to reduce it to sawdust. In this sawing process, the lumber is made to pass between rollers which squeeze out much of the moisture. The sawdust to be carbonized passes to a drying apparatus, heated partly by waste steam from the engine and partly by steam direct from the boiler. This drying plant is located on an upper floor; and from it the dry sawdust is led—by a hopper, to the briquette-presses below. The briquettes are delivered in a continuous string to the adjoining carbonizing apparatus. This latter consists of a number of upright iron cylinders, provided at the bottom with outflow pipes for the products of distillation, and at the top with a cast-iron cover carrying a hydraulic press cylinder.

The process of carbonizing the wood is described as follows: The charge of briquettes is brought by a traveling crane over the mouth of the retort, is lowered into it, and the cover is put in place. Hydraulic pressure is then applied to the cover, forcing it down, and at the same time the fire is kindled in the furnace of the retort. The products of distillation pass through a cooling pipe to a collecting well, whence they are pumped to three reservoirs, and the tar and the wood-alcohol are allowed to separate before undergoing further manipulation. When the charge is completely carbonized, the cover is taken off and a sheet-iron cylinder is placed over the mouth of the retort; and in this latter the charcoal is raised and carried away upon a car to cool. The plant for this process is made at J. & C. G. Bolinder's Mechanical Works, at Stockholm, under Swedish patents.

A series of tests of the process has been carried out by eminent Swedish engineers, and the report quoted goes into very full detail. Summing up the results, we find that to carbonize the briquettes requires the consumption of about 58 lbs. of wood per 220 lbs. of briquettes. In apparatus now being made there will be room for 4,400 lbs. of briquettes in each retort; and with a carbonization of 18 hours per day, for 300 days in the year, the annual product would be 800 metric tons per retort. In the plant described there are eight retorts, with an output of, say, 6,000 tons per year. The fuel used in drying the sawdust and heating the apparatus and the boilers is estimated at half the weight of the briquettes, as a maximum; and a plant of the dimensions described would thus annually require 9,000 tons of lumber waste.

From the 6,000 tons of briquettes are obtained:

	Per cent.	Metric tons.
Charcoal	33.43	2,005.8
Tar	8.34	530.4
Acetate of lime	5.00	300.0
Methylic alcohol and acetone	.75	45.0

At Swedish prices the receipts from this product amount to 206,772 kroners; and including in the expenses 10% for a sinking fund on the capital cost of 300,000 kroners, the profits amount to 68,872 kroners; or $18,251.08, taking the kroner as worth 26½ cts, in U. S. currency.

An analysis of the briquettes at the Royal Technical High School show that the briquette coal is pure charcoal, free from extraneous matter and possessing great solidity and density. A hectoliter of briquette coal, containing 9.4% of water, weighs 36.3 kilos., as compared with 13.8 kilos. for ordinary sawmill charcoal with the same amount of moisture. It is also only one-third the bulk of ordinary charcoal. The tar is of a rather thin quality, and contains a considerable quantity of creosote; as it is uniform in quality it is especially useful for antiseptic purposes. Acetate of lime is used in producing acetic acid; and the methylic alcohol is largely employed in the manufacture of aniline colors and for producing the disinfectant, formalin.

The writer sums up his paper by noting the following advantages of the process: (1) A single system for working up the waste material by first putting it into the form of sawdust. (2) The cost of making the sawdust is amply repaid by the simultaneous mechanical drying and reduced labor cost of handling the product. (3) By reducing the wood to the form of briquettes, the apparatus for carbonizing is reduced in volume, as compared with scantling, as 235 kilos. is to 1,000 kilos. per cu. m. (4) The charcoal produced by the process is of great solidity, and the same products result as from dry distillation. (5) There is great economy in space required as compared with the carbonization of scantling, and no danger from fire—as in the latter process.

WIND FORCE IN TORNADOES.*

A correspondent asks: "Has any competent observer ever been able to make any estimate which you think would be at all near the truth of what the speed of the wind is in the funnel of a violent tornado?"

The following reply by the Chief of Bureau will be of general interest:

Prof. F. H. Bigelow has published on page 633 International Cloud Report, Vol. II, Report Chief of Bureau 1898-99, the results of his computation on the great waterspout seen off Cottage City, Mass., Aug. 19, 1896. He gives the following additional facts: This large tornado tube or waterspout over the ocean was seen from several localities, and the direction noted so that it was easy to place its position on the map with much exactness. At the same time a series of large pictures were photographed by Mr. Chamberlain, of Cottage City, showing the spout in several positions relative to the landscape in the foreground. Professor Bigelow visited the place and made a suitable survey of the distances so that the scale of the photograph was found, and from this the dimensions of the tube and the height of the cloud. By means of the proper formula the following dimensions in feet and velocity in miles per hour, for the different components, were obtained:

Height above sea level. Feet.	Diameter of tube. Feet.	Radial velocity outward. Miles.	Rotational velocity. Miles.	Vertical velocity upward. Miles.
4,200	..	..	..	..
4,193	3,402	7.0	14.1	0.04
3,901	500	1.0	94.4	2.50
3,599	400	0.6	119.5	3.90
3,301	290	0.6	164.0	7.40
2,999	250	0.5	189.0	9.90
2,398	204	0.4	233.0	14.90
1,802	178	0.4	268.0	19.80
1,499	168	0.3	284.0	22.20
1,201	158	0.3	300.0	24.70
901	144	0.3	328.0	29.60
479	144	0.3	333.0	29.70
0	134	0.3	354.0	34.00

A more thorough study of the data shows that the lower portion of the vortex tube is enlarged over these diameters on account of the friction due to disturbing the water, to the raising of the spray to a height of 500 ft. when it is cast out of the tube, and to the indraft of air required to supply the vortex. The effect of this is to increase the size of the tube at the ocean to about 200 ft., and to reduce the rotating velocity to about 300 miles per hour, and the vertical internal draft to about 30 miles per hour. These dimensions and velocities characterize the largest tornado tubes, and together with the fall of internal pressure by the amount of 3 or 4 ins., they readily cause the destructive effects noted so conspicuously at Louisville, Ky., and St. Louis, Mo., in recent years.—H. H. K.

*From the "Monthly Weather Review."

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The fatal disaster on the Liverpool Overhead Ry. on Dec. 23, should call general attention to the need of greater care in wiring and equipping electric cars. According to the cable dispatches, it appears that a blowing fuse set a car on fire just as it was passing between high stacks of creosoted ties which were piled on each side of the track. The fire spread so quickly and egress from the burning train was so difficult, that seven persons were burned to death and many others barely escaped with their lives.

It need not be argued that because the accident happened in England it carries no lesson for American railway managers. As a matter of fact, fires on electric cars set by blowing fuses are altogether too common in this country. Only a few days ago a car on the Broadway line in New York city, was set on fire by the electric current and the fire spread so rapidly that one passenger at least was injured by burns before he could be rescued, and the entire car was destroyed before the fire company could extinguish the flames. This happened, moreover, on a car running in the open street, where escape was easy. What might the result have been, had the car been on an elevated railway, or in a subway, or at the center of a three-mile tunnel under the Hudson River, such as the Pennsylvania R. R. is to build? The cases of burning cars which we have cited are not isolated and exceptional either. Some experiences of this sort on the Washington electric railways were described in our issue of Oct. 17. There are plenty of these cases occurring all the time of cars set on fire by blowing fuses or other faults in the car wiring. As a usual thing, of course, the passengers rush out, the blaze is soon extinguished, and there is an end of it. It will not be so easy on an elevated road or in a tunnel to escape from such cars or to extinguish fires when they start. In view of the large number of projects now on foot which contemplate the use of electricity for traction on elevated and underground railways, the warning given by such accidents as that at Liverpool should be heeded.

If there is any reason why car fuses and switches cannot be so surrounded with incombustible material as to prevent such accidents (?) we have yet to hear it.

THE IMPROVEMENT OF FREIGHT CAR INTERCHANGE TRAFFIC AT CHICAGO.

The prompt and economical handling of freight traffic at Chicago, where approximately 10,000 cars have to be handled daily, is in itself a difficult problem, which is further complicated by the necessity of arranging for the transfer of through cars from one road to another. It is estimated by competent authorities that from 60 to 65 per cent. of all the freight traffic entering Chicago consists of through freight, or cars which come in over one road and have to be transferred to other roads over which they are to continue their journeys. This may involve a haul of as much as 16 miles from the inbound yard of one road to the outbound yard of another road, and a delay of as much as 24 hours in the transfer between the two yards. The remaining 35 to 40 per cent. of the traffic consists of freight destined for the Chicago terminals, local yards and industries.

Under the present system of operating the transfer or interchange traffic, each of the trunk lines centering at Chicago has to maintain yards in which inbound trains are broken up, cars sorted for distribution, and outbound trains made up. The inbound cars to be transferred to other roads are either taken by switch engines to the yards of these roads, or are collected and distributed by one or other of the terminal and belt lines which connect the freight terminals of the various railways. It is estimated that from 50 to 60 per cent. of the cars are transferred by the roads themselves with their own engines, the remaining 40 or 50 per cent. being transferred by the belt lines. If a road has only a few cars for interchange, it is more economical to turn them over to a belt line for transfer, but with a large number of cars, say 50 or more, it would be more economical for the road to run its own engines. Both the railways and the belt lines make regular schedule trips to serve these terminals, and at each yard or terminal the inbound cars for transfer must be switched to separate them from local cars and then arranged for delivery to the other terminals in the order in which they will be reached by the transfer or belt-line train. When the cars are delivered to these terminals as outbound cars, they must again be switched in classification yards to put them in the required position in an outbound train.

This process of transfer of through cars involves much delay and work incident to the switching at the yards of the two roads and the transfer between these yards, which requires in many cases a considerable length of haul over the connecting or belt lines. Transfer over a belt line may take as long as 24 hours, as above noted. Further delay occurs from the fact that a through car of a main line train arriving after the schedule time of the transfer train must be held for several hours before it can be sent out to the other road, in whose yard it may again miss an outbound train and so incur still further delay. If the freight is of special importance, of course, a special trip may be made to take it to the other road, but this is an expensive proceeding. Another source of delay lies in the fact that under the present lack of a general system, or of concerted action, a switch engine delivering cars to one road very often does not take back cars destined for its own line, but leaves the second road to do this with its own engines. This particular feature is discussed further on.

Several of the railways have two or more freight yards, so that the 20 trunk lines and the connecting and belt lines operate from 25 to 30 yards in all. The distance from yard to yard varies from 500 ft. to 16 miles. The number of interchange trips to each yard varies from 1 to 4 per day, and the number of cars interchanged at individual yards varies from two or three to as high as 200 and even 300 per day. The time occupied by an engine in making a round trip between two yards varies from half an hour to five hours, and the engines generally return light although they sometimes take return loads to the starting point or to other yards. The switch engines at any one yard make an aggregate of from 2 to 20 round trips daily (for all the engines together). The total number of cars interchanged daily by 20 railways averages about 7,200, and their transfer involves about 264 engine round trips, with an aggregate engine mileage of 2,400 miles. The above figures, however, do not include the Chicago & Western Indiana Ry., the Chicago Junction Ry., the Atchison, Topeka & Santa Fe Ry., the Chicago, Lake Shore and Eastern Ry., or the Elgin, Joliet & Eastern Ry. The Chicago & Western Indiana Ry. (Belt Line), which operates interchange traffic almost exclusively, makes from two to eight trips daily, and handles about 2,000 cars per day. These figures represent a careful canvass of the interchange traffic, and are supported by official records. With this enormous traffic between all the trunk lines, and with each road operating its own share largely independent of the others, it may readily be imagined that the complications and delays are very serious and involve considerable expense.

Two methods are open for the improvement of this interchange service, both from a traffic and a financial point of view: First, the adoption of an entirely different system of operation; and, second, the modification of the present system.

The first of these methods, namely, the adoption of an entirely new system of handling the interchange traffic, is the basis of the enterprise of the Chicago Transfer & Clearing Co., whose new switching and transfer yards are described in another column. The fundamental principle of this enterprise is to avoid much of the work of switching in the various yards, and the delays incident to this switching and to the transfers between the yards, by centralizing the switching and transfer operations at one point, away from the busy city lines, and by having all this work done by the transfer company instead of by the individual roads. With this system in operation in conjunction with the present method of handling traffic, an inbound freight train arriving at the yard of one road may have all its through cars switched out and set aside without any attempt at classification. At the proper time these may be sent direct to the transfer yards, there to be distributed upon special tracks for the various roads over which they are to be sent out, being also classified as required by these roads in the manner described elsewhere. Each road would be able to make its own schedule, delivering cars at its convenience, and generally at such a time that the engine could take back cars (from various roads) for its own road in time to be made up in an outbound train. This system may be aptly compared to the clearing-house system in banking, by which each bank in a large city sends all checks received on other banks to a clearing house which distributes the checks to these various banks, instead of each individual bank sending its own messengers to all the other banks.

Still greater facility for the prompt handling of through freight traffic may be afforded by the railways themselves, operating in conjunction with the transfer company. It has already been shown that this through traffic represents 60 to 65 per cent. of the traffic entering Chicago. Each railway might operate its division yard nearest to Chicago (approximately 100 to 150 miles distant), as a classification point for the separation of through cars from cars destined for Chicago. Solid trains of through cars would then be made up at the division yard and taken direct to the Chicago transfer yard, where the cars would be distributed to the various roads over which they are to be forwarded. In the same way, solid trains of through cars for individual roads might be made up in the Chicago transfer yard and taken out direct by the road engines, without occupying the city lines or terminals at all. The cars destined for Chicago would also be made up in solid trains at the division yards already mentioned, and these trains would be run direct to the main city yards of the railways, and thence distributed to the local yards, freight houses,

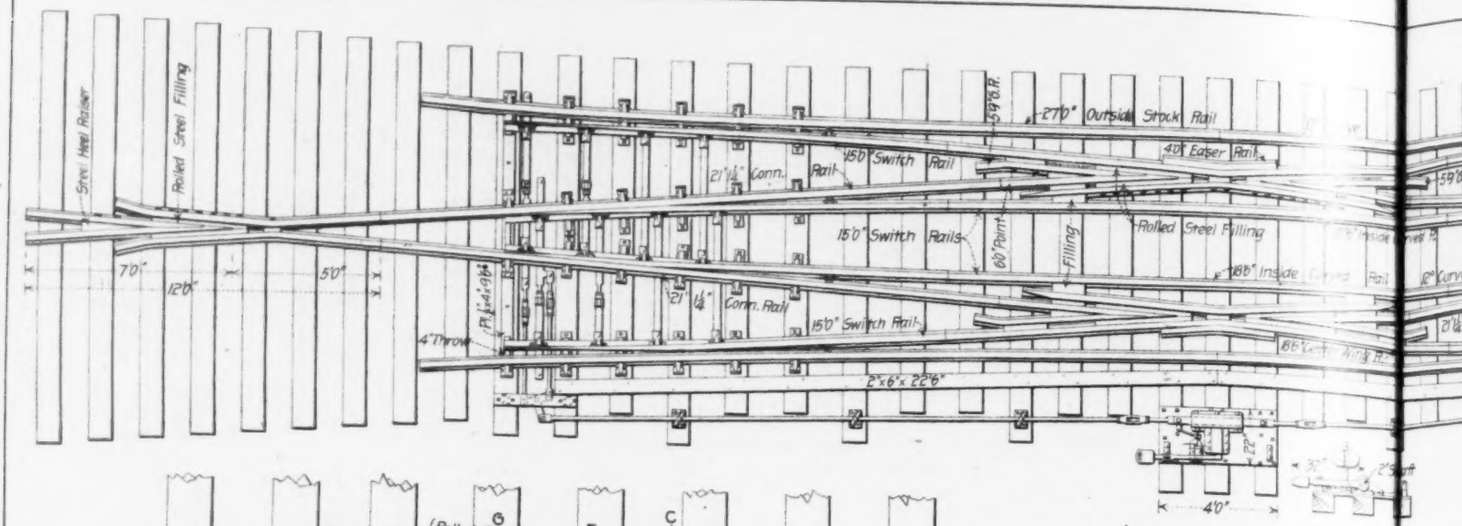
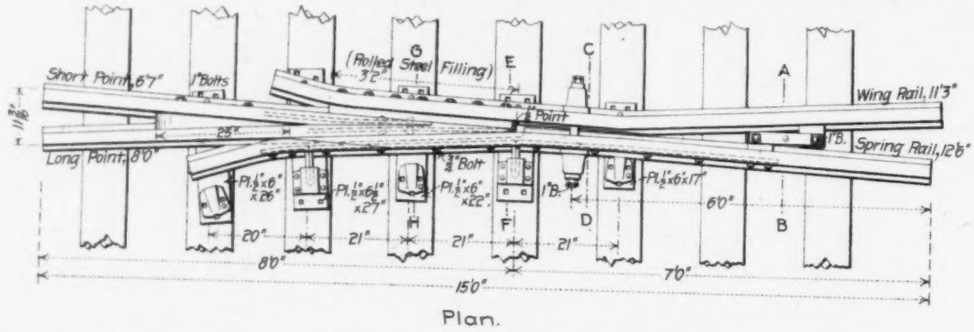
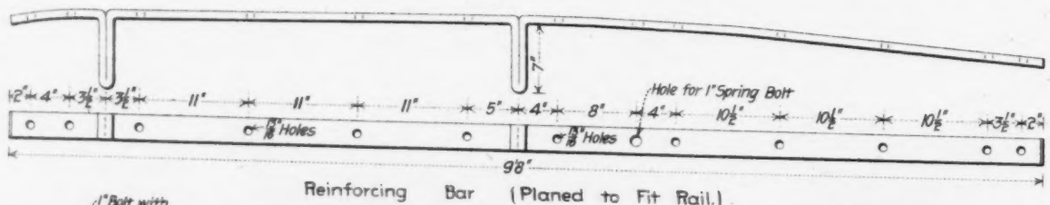


FIG. 8. DOUBLE SLIP SWITCH AT SUMMIT.





Reinforcing Bar (Planed to Fit Rail.)

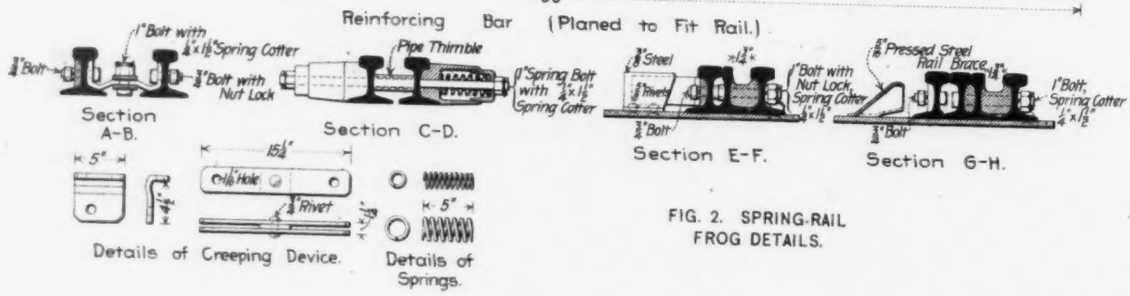


FIG. 2. SPRING-RAIL FROG DETAILS.

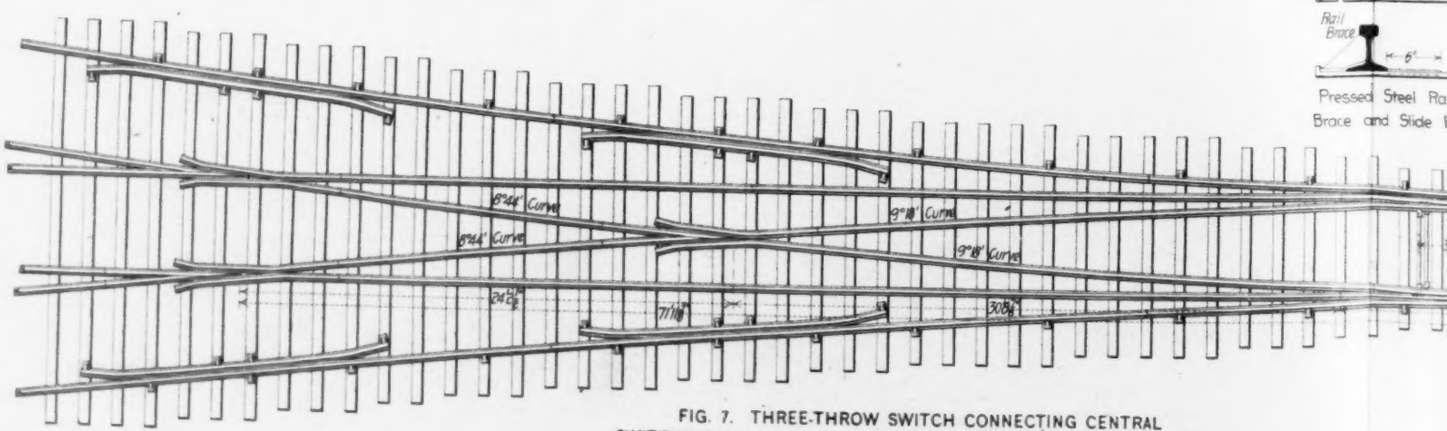
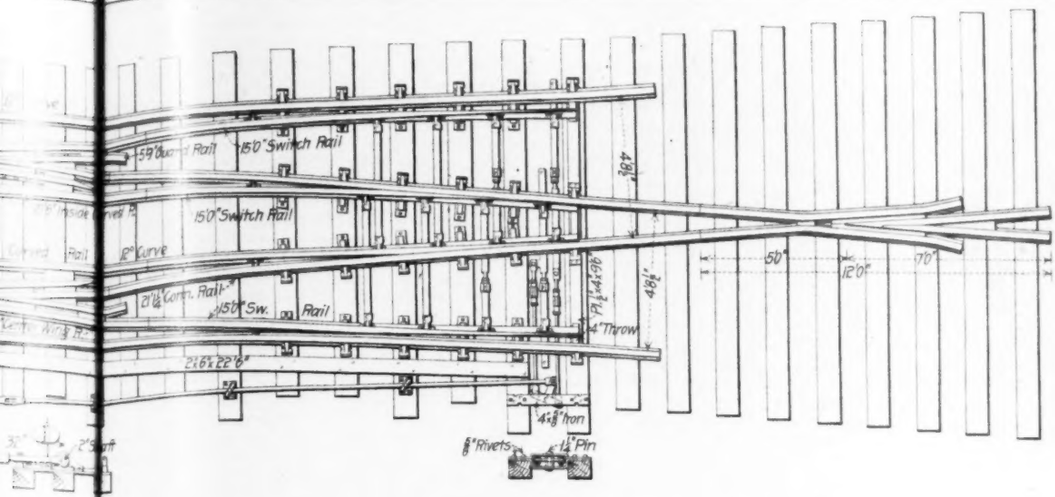
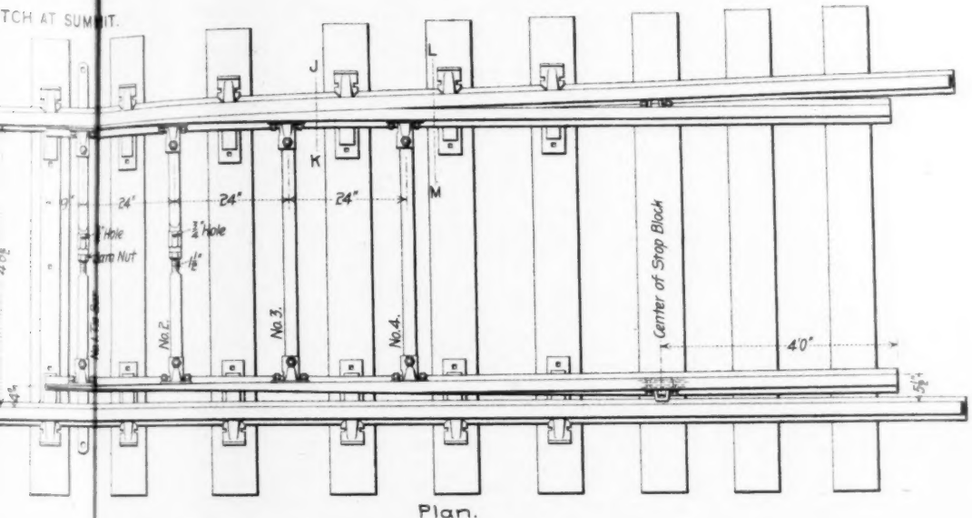


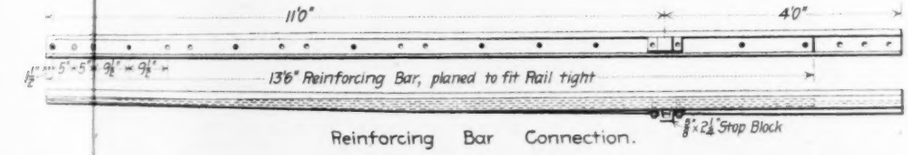
FIG. 7. THREE-THROW SWITCH CONNECTING CENTRAL SWITCHING-TRACK WITH THOROUGHFARE AND TWO LADDER TRACKS.



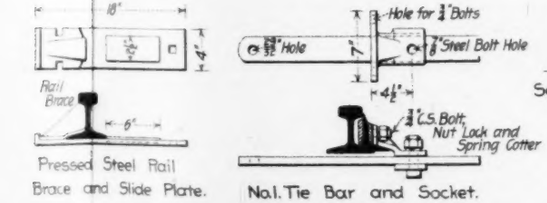
TCH AT SUMMIT.



Plan.



Reinforcing Bar Connection.



Pressed Steel Rail Brace and Slide Plate.

No.1. Tie Bar and Socket.

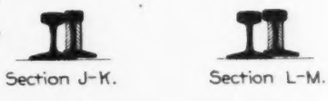
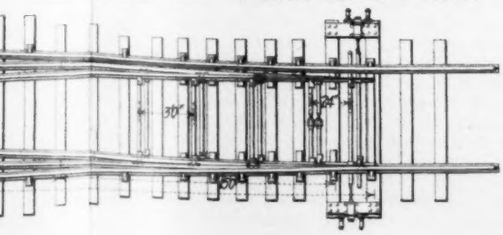


FIG. 1. DETAILS OF SPLIT SWITCH.



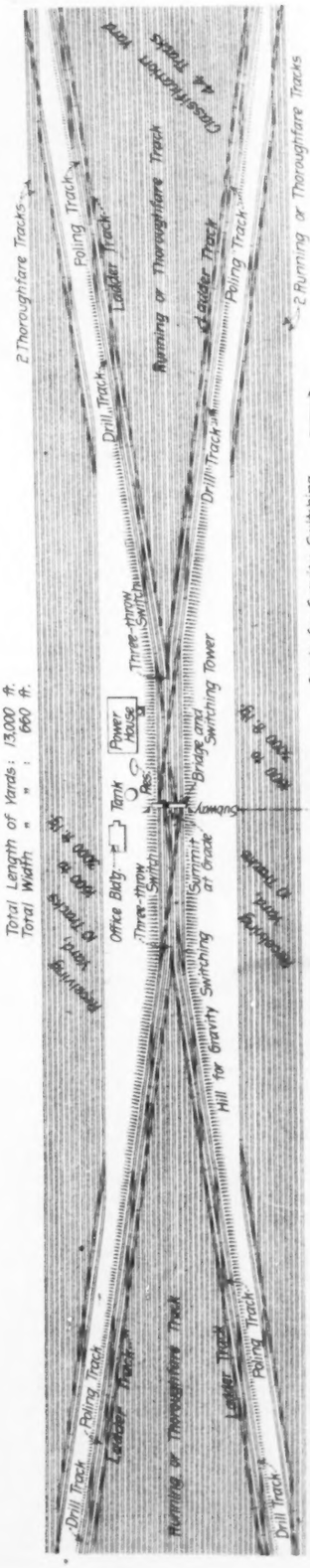


FIG. 4. PLAN OF TRACKS AT CENTER OF YARDS

GRAVITY SORTING YARDS, SWITCHES AND FROGS OF THE CHICAGO TRANSFER AND CLEARING CO., CHICAGO, ILL.

A. W. Swanitz, Chief Engineer.

CHAS. HART, LITH., 26 VESEY ST., N. Y.

team tracks, industries, etc., to be unloaded. In this way the city terminal lines and yards would be relieved entirely of all the through traffic, which at present causes serious congestion of the business, and hampers the proper handling of both through and local traffic.

With this transfer system carried out in its entirety, it would not only reduce the time occupied by cars in journeying to their destination, but would greatly reduce the number of switch engines required by the individual roads, and also greatly reduce the switching movement and mileage of both engines and cars. As to the saving in time, it is estimated that the time occupied in switching and transfer might be reduced at least two hours by the new system operated in connection with the present method of handling the traffic; or reduced by at least four hours by the new system operated in connection with the method outlined in the preceding paragraph. Another very important point is that very close connections could be made with the regular outbound evening fast-freight trains. At the present time close connections may be made at a few points, but in most cases a long transfer is required, while at the transfer yards a car could be transferred from the inbound train to the outbound train of any road in about half an hour. The central transfer system would also relieve the congested city terminal lines, yards, freight houses, etc., of the various individual railways of much of their present traffic, and might enable the present main yards (many of which occupy valuable land) to be reduced in size. The payment for this transfer service by the railways might reasonably be on the basis of a flat or stipulated sum for each car handled, with extra charges for car repairs, icing refrigerator cars, watering stock cars, etc.

The new transfer system also affords an opportunity for development on the lines indicated in the brief description of this system in our issue of June 13, 1901. For instance, provision might be made for consolidating small or "less-than-carload" shipments for the same points into full car loads, thus releasing cars for service and economizing in the transportation expenses. The general operation of such a plan would be similar to that of the Great Northern Ry. transfer station at Minneapolis, or that of the Pennsylvania Lines at Fort Wayne, where all freight for outbound trains is consolidated into full car loads. Here, also, freight received by one road in single carloads for another road, would be transferred by the former for distribution over its own line. Thus a carload of freight delivered by the Pennsylvania Lines to the Chicago & Northwestern Ry., at Chicago, might include some goods for delivery by way-freight trains starting from Chicago, and other goods to be sent by fast-freight trains to different parts of the C. & N. W. Ry. system. The transfer of freight for either consolidation or distribution, as above described, could very conveniently be carried on at the transfer yards, thus relieving the Chicago freight houses of much of this business. Other facilities to be provided might include grain elevators, coal storage, the watering of stock trains, icing of refrigerator cars, etc. It has also been suggested that extensive warehouses might be built to be used for storage by the large wholesale and commission houses of Chicago, which would thus be able to receive and ship goods direct at these warehouses, without the delay and expense incurred in hauling all their goods by teams between their city warehouses and the various railway terminals in the city. The establishment of manufacturing industries in the vicinity of the transfer yards might also be considered as an auxiliary proposition. All these matters, however, are for future consideration, and are not necessary to the operation of the transfer yard itself. This yard is now practically completed and ready for operation, and the effect of the new method of operating will be watched with interest.

So much for the introduction of an entirely new system of handling the interchange traffic, and now we may consider the question of improving the present system of operating. There is no doubt whatever that this system, which has already been described, is capable of improvement, although one very serious obstacle in the path of the reformer is the difficulty of obtaining harmonious action on the part of the officers of the several roads.

One of the principal openings for improvement is the reduction of the light mileage of the switching engines, by giving them return loads. A great cause of delay to interchange cars lies in the fact that under the present system, with little reciprocal arrangement or concerted action between the various roads, and also on account of certain prejudices, when an engine from one road (the A. & B. Ry.) delivers cars to another (the Y. & Z. Ry.), it may not take back cars destined for its own road and waiting in the Y. & Z. yard. The A. & B. Ry. engine returns light to its own yard, and the cars from the Y. & Z. Ry. are later on delivered to the A. & B. Ry. by an engine of the Y. & Z. Ry. This means that two engines each make two trips, one loaded and one light, whereas one engine might have done the work in less time and at less expense, by making two trips loaded This arrangement, of course, increases the number of switching engines and crews unnecessarily, together with their mileage and expenses (about $2 per crew per hour). It would be much more systematic and economical (both in time and money) to so arrange that the A. & B. Ry. engine delivering cars from its road to the Y. & Z. Ry., could return with cars from the latter road for the A. & B. Ry. The engines of the Y. & Z. Ry. would work in the same way, and at the end of each month a balance would be made up to adjust the service rendered. Thus, if the A. & B. Ry. (with its own engines) had brought from the Y. & Z. Ry. more cars than the Y. & Z. Ry. had collected from the A. & B. Ry., then the Y. & Z. Ry. (having done the lesser proportion of the work) would make a payment to the A. & B. Ry. on the basis of service performed. Under present practice this would be about 25 cts. per car, but it is generally felt that this is too high, and probably 20 cts. per car would be a better charge.

Under the present system, the crew of the delivery engine cannot demand that cars for their own road be delivered to them in return, even if the cars are ready. On the other hand, the yardmaster may compel the crew to take these cars, if he chooses to do so. If arrangements could be made by which the crew could demand that cars waiting to be sent to their road should be delivered to them, it would much facilitate the movement of cars, and reduce the light engine mileage, with consequent reduction in engine expenses for transfer service. If the cars were not quite ready to be delivered, the engine might wait a reasonable time (not more than half an hour) before starting on its return trip.

Of course, there are various incidental conditions which might prevent this being done in every case. The delivering engine does not always return to its starting point; it may go into another yard to do switching work or pick up a train, or it may have to collect or pick up cars from industries and spur tracks. Sometimes it may not be economical to get the cars ready at the time the foreign engine arrives, the amount of business may not warrant putting the arrangement into effect, or space may be too limited to provide the necessary track accommodation. In some cases, also, the foreign engine reaches the yard over a common interchange track and must promptly get out of the way of other engines, while the different conditions of working of a trunk line and a belt line must also be taken into consideration.

But after due weight has been given to the various objections, it still appears certain, as the result of very careful inquiry among the railway officials themselves, that nearly three-fourths of the present interchange traffic could be greatly facilitated by the adoption of reciprocal traffic relations between the yards of the various railways. Some slight changes in the methods of operating the yards might be required, but these would be an improvement rather than an impediment to the yard work. The matter has been taken up for consideration by the Chicago Association of General Superintendents, which will undoubtedly act upon it in such a manner as to do away with much of the light mileage.

A careful compilation has been made from the traffic records of about 20 of the railways entering Chicago, exclusive of certain lines, as already mentioned. From this it appears that the daily interchange traffic of these 20 lines averages 7,200 cars, with 2,400 engine miles, requiring 530 hours of engine service. The total number of round trips of the engines averages 261 trips per day. In about 45 per cent. of these trips the engine makes the whole or part of the return trip with a full or partial load (which practically means that a large proportion of the return mileage is made light). In 41 per cent. of the trips the engines return entirely light, while in 14 per cent. some form of reciprocal arrangement is in effect between the roads concerned. These arrangements may be of different kinds, as follows: First, each road makes its own trips, and (under agreement with the other roads) brings back cars destined for it; this has the advantage of keeping the same number of engines continually in service. Second, one road does all the work, and charges the other road for its share of the cost. Third, each road does all the work in alternate months or weeks. There are modifications of these plans, as where one road, A, brings cars of its own and another road, B, to its own yard; whence B picks up its own cars and takes them to its yard.

A discussion of the car interchange system would hardly be complete without some reference to the intricate system of inspection of the interchange cars, to ascertain whether they are in safe and proper condition to continue their journeys. Much time and care have been devoted to formulating the "rules of interchange" and in developing honest and thorough inspection and records of inspection. At the same time, as each road has its own inspectors, they are naturally inclined to do the best they can for their own roads, and this militates against exact uniformity in practice. Thus, for instance, one road may agree to accept certain private-line cars which do not fully meet requirements as to sizes of axles, etc., and which cars another road refuses to accept for this reason. The former road may, therefore, get the larger share of this particular shipper's business. It has been suggested, and the suggestion seems reasonable, that the inspection at such a point as Chicago should be in the hands of an independent inspection bureau, representing all the railways, but independent of them, and appointing its own inspectors. In this way the decisions of the inspectors would be unbiased, and would apply uniformly to all cars offered for interchange. Such a bureau might well be maintained in connection with the new single interchange or transfer yards already referred to and described in detail elsewhere.

THE REPORT OF THE ISTHMIAN CANAL COMMISSION.*

WILL THE CANAL PAY?—On no subject in connection with the proposed piercing of the Central American Isthmus has there been greater divergence of opinion than on its probable traffic. Enthusiasts have declared that the yearly benefits accruing to the world by constructing the canal could only be measured by hundreds of millions, while extremists on the other side have declared that the canal would hardly be used at all by ocean commerce. In the absence of any available statistics or systematic study of the subject, it has been easy to make such statements and hard to disprove them. We have always contended that before the nation invested its money in any such enterprise, a thorough expert study should be made of the traffic which would seek such a canal, and the benefits, direct and indirect, that might accrue from its construction.

Such a study has been made by the Isthmian Canal Commission, and its results are of great interest. We may briefly summarize them as follows:

Studies of the foreign commerce of the United States, of European commerce with the western part of the American continents, of Australasia with northwestern Europe, and of Panama Ry. traffic, indicated a total net registered tonnage that might have used an Isthmian canal in 1899 amounting to 4,575,000 tons. To arrive at the traffic which might use such a canal in 1914,

*The portions of the Commission's report dealing with the relative advantages of Nicaragua and Panama and with the adopted route across Nicaragua were reviewed in our last week's issue.

when it is supposed the canal may be opened, it is assumed that traffic will increase 25% per decade—this being the rate of increase of ocean commerce between Europe and Pacific America in the decade 1888-1898. This would make a total possible traffic for the canal at its opening in 1914 of 6,400,000 net registered tons. To predict the ratio of growth after the canal is opened comparison is made with the Suez canal and it is estimated that the traffic may amount to 10,500,000 tons to 11,375,000 tons in 1924.

But the extent to which the canal will be used by vessels will be largely influenced by the rates of toll charged. A toll of about $1 per net ton register could be paid by vessels plying between Europe and the west coast of South America or by vessels plying from the Atlantic seaboard to Australia; but a much higher charge than this would cause such traffic to keep its present routes On other routes, too, the rate of toll will be an important factor in determining the use of the canal Let us assume the Nicaragua route to be selected the tolls to be fixed at $1 per ton, and the traffic at the opening of the canal to amount to 6,400,000 tons, or an annual gross revenue of the same number of dollars. Deducting from this sum the Commission's estimate for the annual cost of operating and maintaining the canal ($3,300,000), we have left $3,100,000 as net income on the investment made in the canal. The total cost of the Nicaragua canal is estimated by the Commission at $189,894,000; but this estimate includes nothing for interest on the investment during the eight years required for construction, neither does it include the expenditure which may be required to secure the necessary concessions from Nicaragua and Costa Rica.

Nothing more need be said to show that as a commercial enterprise, to be carried out for profit, by a private corporation, an Isthmian canal is impracticable. It would not be possible to obtain capital for any such enterprise involving such large risks and so small a measure of profit in proportion to the investment required.

As a government enterprise, however, the project stands on a different footing. If the nation undertakes the work, all uncertainties as to its financing vanish. The nation would undertake it not for the direct profit to be gained, but for the general benefit to its people. Indeed, this motive constitutes the real justification for the construction of the canal as a national enterprise. The United States would not be warranted in undertaking any work whose sole purpose was the profitable investment of moneys raised by public taxation. National construction of the canal is warranted only because of the benefits which will accrue to the nation as a whole.

The Commission believes that the canal will particularly benefit the Pacific States, the South and the Northeast by the short and cheap water route which it will furnish to commerce between the Atlantic and Pacific coasts, and also to commerce between the Atlantic coast ports and the Pacific coast of South America, Asia and Australasia. It further holds that the canal will assist the United States in its competition with Europe for the trade of countries on the eastern coast of Asia.

A great deal has been said regarding the value of the canal as a factor in national defence. The Commission devotes a special chapter of its report to this subject, and it is of particular interest because of the representation of the Army and Navy on the Commission. After discussing the questions of neutralization, fortification, etc., the Commission expresses its final conclusions as follows:

> It is the opinion of the Commission that a neutral canal, operated and controlled by American citizens, would materially add to the military strength of the United States; that a canal, whether neutral or not, controlled by foreigners would be a source of weakness to the United States rather than of strength; and that a canal not neutral, to be defended by the United States, whether by fortifications on land or by the navy at sea, would be a source of weakness.

We heartily commend this conclusion and the statements in the chapter which it summarizes to the Congressional and editorial warriors who have so strenuously contended for the fortification of the canal, and for its "Americanization." Doubtless many of these speakers and writers assumed their position in entire good faith, but they simply revealed their lack of expert knowledge respecting the science of modern warfare The controversy over the question of fortification is doubtless over for the present, but if it is ever revived again it is to be hoped that the Commission's expert advice may be quoted and heeded in the halls of Congress.

It is entirely clear now that the commercial and industrial value of the canal far outweighs its military value in the minds of the Commission The canal will not, in all probability, pay the United States more than a very small return upon the money it invests in it. The nation must be content to invest perhaps $200,000,000 in round numbers and receive no income from it during the years of construction and for a decade afterward only enough to pay the cost of maintaining and operating the canal and at most a return of 1 per cent. to 1½ per cent. on its investment.

It may be urged, perhaps, that the Commission's estimates of traffic are too conservative, and that the growth of traffic will be so vast as to make the canal pay a profit far in excess of that estimated. Comparison with the Suez canal, where the traffic after 30 years of use only amounts to 11,000,000 tons, does not encourage such a supposition; but even if we admit a chance for larger profits than the Commission has estimated, they would no more than offset the risks that some great and unforeseen difficulty or calamity may cause the cost of the canal or of its operation and maintenance to far outrun the engineers' estimate.

RISKS DUE TO EARTHQUAKES, CLIMATE, ETC.—We have just alluded to risks of this sort as fairly offsetting the chances of extraordinary profit from the canal enterprise. So much has been said by the advocates of both the Panama and the Nicaragua routes respecting the dangers and risks of this class on the two routes that the Commission has wisely devoted a special chapter to this subject. The Commission finds that the entire Central American isthmus is a volcanic region and is more or less subject to earthquakes A catalogue of recorded earthquakes from the Spanish Conquest to 1888 shows 14 earthquakes on the Nicaragua route and 28 on the Panama route. In 1844 Rivas was almost destroyed and great damage was done at Greytown. In 1882 part of the front of the Cathedral at Panama was thrown down, crevasses were opened at Colon and some lives were lost. The masonry of three or four bridges and culverts on the Panama R. R. was damaged.

The record is not complete or full enough, however, to justify any comparison between the two routes. On either route it is possible and even probable that the more accurately fitting parts of the canal works, such as the lock gates, may at times be distorted by earthquakes. Such damage can be provided against and repaired, just as damage from accidental collision of a vessel with a gate would be repaired. It is also possible that a fissure might open and drain the canal; possibly even destroy it. But "If a timorous imagination is to be the guide, no great works can be undertaken anywhere." The Commission holds that such danger as exists from earthquakes is essentially the same at Nicaragua and at Panama, and in neither case is it sufficient to prevent the construction of the canal.

The greatest difficulty to be met in the construction of the canal is likely to be the procuring of an adequate force of laborers and the preservation of their health and efficiency. In this respect Nicaragua possesses some advantages over Panama; but at either place great care must be exercised by those responsible for the conduct of the work. The requirements for successful prosecution of the work are enumerated by the Commission as follows:

> Careful selection, including physical examination, of persons sent to the Isthmus; a well-organized hospital service; an efficient sanitary supervision of camps and barracks; a rigid quarantine service; a liberal water supply and sewerage system; the authority and police force necessary to enforce the rules; regular leaves of absence for white employees.

We need look no further back than the assembling of the military camps at Chickamauga and the experience of the American army at Santiago to see what the inevitable result would be of the establishment of ordinary contractors' camps on the line of the Nicaragua canal. Such thorough sanitary precautions as the Commission has advised will be absolutely essential at the very outset. One carelessly and slovenly kept contractor's camp might become a center of infection for the entire work. The reputation which one season of disease and epidemic on the Isthmus might give would make it practically impossible to induce laborers to go there except at wages so high as to greatly increase the cost of the work. It can safely be asserted that every penny spent to safeguard the health and the comfort and to prevent drunkenness and vice among the many thousands who will be employed on the canal construction will pay a direct return in a final lessened cost for the work.

To make possible the strict supervision of the working force is one of the reasons, doubtless, why the Commission recommends that the United States obtain control not only of the canal line but of a strip at least five miles in width on either side. Such control, it is evident, must include the right not only to make and carry out police regulations, but to enforce contracts relating to the construction and operation of the canal. Nominal sovereignty over the strip need not be relinquished by the State granting the concession; but it is clear that the remnant of sovereignty left would be nominal indeed.

DIMENSIONS AND UNIT PRICES.—We gave last week a brief description of the route adopted by the Commission for a Nicaraguan canal. We now conclude our review of the report by notes on the dimensions and unit prices which it has adopted as the basis for its estimate.

The size of the canal prism exceeds that of any existing ship canal as well as the dimensions adopted by the preceding commissions which have officially studied the Nicaragua route. The depth is to be 35 ft. throughout. The bottom width is to be 150 ft., widened on curves of less than 12,000 ft. radius and 500 ft. width of channel in the proportion of 1 ft. for each 200 ft. reduction of radius. The side slopes are to be: in soft earth or sand, 1 on 3 below water and 1 on 2 above water; in firm earth, 2 on 3 below a berme 10 ft wide, 6 ft. under water and 1 on 1 above such berme, the last-named slope protected by paving. In rock, the sides are vertical from the bottom to a berme 5 ft. above water and from 5 on 1 to 2 on 1 above the berme, according to the material. The berme is to be of such width that the extended slope would intersect the bottom of the canal at the foot of the vertical wall.

Channels in open water are much wider than the above. In the San Juan River 250 ft., in Greytown Harbor 500 ft., and in Lake Nicaragua 300 ft. are examples.

The lock chambers are to be 740 ft. long, 84 ft. wide and 35 ft. over the miter sill. Twin locks are provided in every case to permit navigation to continue while one lock of a set is under repair. Guard gates are placed at both ends of every lock to further facilitate repairs to lock gates. To make the operation of the locks more rapid and economize water in handling moderate-size vessels, intermediate gates are provided, by which the lock may be used either as a 292-ft. lock, a 400-ft. lock, or for its full length.

All locks are founded on rock and lock gates are to be of steel. Concrete is used for nearly the whole of the lock construction, granite being provided only for quoins, copings and exposed angles. Lock culverts are to be lined with cast iron, or with vitrified brick, according to the velocity of water through them.

The unit prices adopted by the Commission are printed below. It should be noted that in making up the estimates, 20% was added to the sums obtained by use of these unit prices to provide for engineering, police, sanitation and general contingencies. It is further noted that the prices are based on efficient organization and thorough equipment, with the understanding that while the work will be vigorously handled it will not be so driven as to call for unnecessary duplication of machinery:

Removal of hard rock, per cu. yd.	$1.15
Removal of soft rock, per cu. yd.	.80
Removal of earth, not handled by dredge, per cu. yd.	.45
Removal of dredgable material, per cu. yd.	.20
Removal of rock, under water, per cu. yd.	4.75
Embankments and back filling, per cu. yd.	.60
Rock in jetty construction, per cu. yd.	2.50
Stone pitching, including necessary backing, per sq. yd.	2.00

Clearing and grubbing, in swamp sections of Nicaragua, per acre	200.00
Other clearing and grubbing, on both routes, per acre	100.00
Concrete in place, per cu. yd.	8.00
Finished granite, per cu. yd.	60.00
Brick in culvert lining, per cu. yd.	15.00
All metal in locks, exclusive of machinery and culvert linings, per lb.	.075
All metal in sluices, per lb.	.075
Cast iron in culvert lining, per lb.	.04
Allowance for each lock-chamber for operating machinery	50,000.00
Additional allowance for each group of locks for power plant	100,000.00
Price of timber in locks, per M. ft. B. M.	100.00
Sheet piling in spillways, per M. ft. B. M.	75.00
Bearing piles in spillways, per lin. ft.	.50
Caisson work for the Conchuda Dam, in place, per cu. yd.	20.00
Single-track railroad, complete, with switches, stations, and rolling stock, per mile of main line	75,000.00

LETTERS TO THE EDITOR.

Another Explanation of the Fairhaven Water-Tank Failure.

Sir: I submit an explanation of the failure of the water tank at Fairhaven, Mass., described in your issue of Nov. 21, which I believe accounts for the hole in the pavement and the rupture in the conical bottom; in fact, for the entire behavior of the tank and its collapse.

It seems to be the prevailing impression that the bottom was subjected to annular tension. I think the following will show that it was really subjected to little or no tension, and this is the reason why it failed.

Suppose the bottom were conical in shape throughout, instead of having a spherical-shaped terminal piece, and the dimensions were as indicated in the accompanying diagrams, the slope of the bottom being 45°. This will approximate the true conditions, and will serve to illustrate the point in question. Assume the tank to be filled to a depth of 40 ft. That is, that a cylinder of water 40 ft. high and 35 ft. in diameter is pressing on the bottom, and that the unit pressure for the entire bottom is the same. This, of course, is not quite true, for the pressure at the greater depth is greater, but the assumption will simplify the calculations.

Fig. 1.

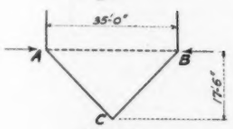


Fig. 2.

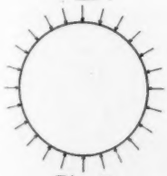


Fig. 3.

Diagrams Illustrating a Theory of the Fairhaven Water Tank Failure.

The weight of this cylinder of water is about 2,405,000 lbs. This entire weight rests on the conical bottom, and must be transmitted to the support through radial tension in the direction of the elements of this cone. Since these elements are inclined to the horizontal at 45°, the vertical and horizontal components will be the same. The vertical component is the weight of water or 2,405,000 lbs. This is the amount, then, of radial pressure applied around the rim as indicated in Fig. 3. By referring to Fig. 1 it is seen that there is nothing of any consequence to take this radial force. The 6×4-in. angle would take but a small part of it. It must therefore go into the conical bottom itself and produce an annular compression. This radial pressure on the periphery would be about 21,900 lbs. per ft. The equivalent pressure on the diameter is then $21{,}900 \times 35$, or 766,500 lbs.

But there is a pressure acting in the opposite direction to offset this, namely, the pressure outward on the conical bottom itself. On the diameter this will be the area of the triangle A B C times the pressure of water at 40 ft. depth, or $35 \times 17.5 \times 40 \times 62.5 \times \frac{1}{2} = 765{,}600$ lbs.

The resulting radial tension is thus about nil. This makes the conical bottom in effect a flat plate, since it lacks the radial tension to hold it in shape. The stresses are those that would produce buckling and the local outward pressure would tend to bulge out the bottom. Unstable equilibrium and the springing of the joints in the bottom would be the most natural consequence. The point of initial failure would naturally be one of the radial seams in the bottom. After this had bulged out the annular compression in the bottom which supported the weight of the water would take another course and immediately be turned into tension in the direction of the elements of the conical bottom. This would unseat the tank from its support, since it was not attached to the top flange of the circular girder. The ripping of the joint of the conical bottom and the vertical sides would be inevitable.

If there had been a horizontal circular girder in the plane of the top flange of the circular girder used, of sufficient strength to take the annular compression referred to and attached to the flanged plate of the conical bottom with enough rivets to take the 21,900 lbs. per ft., the conical bottom would be left to perform its proper function and would be in tension only. If this had been the case the tank would probably be standing to-day.

Yours truly, Edward Godfrey.

Western University of Pennsylvania,
Allegheny, Pa., Dec. 12, 1901.

Junction Details for Sides and Bottoms of Elevated Steel Tanks with Curved Bottoms.

Sir: In response to the inquiry in your issue of Dec. 5 for the results of experience with different forms of junction between sides and bottom of elevated steel tanks, I enclose a blue print showing details from a recent design for a small tank, which are substantially the same as used by me for the tank at this college, which is 24 ft. in diameter by 40 ft. in height above the joints shown. We had no trouble in erecting this joint and no trouble whatever in calking, or with leaking since erection. I know of a number of other tanks built with full hemispherical bottom in very much the same way, and with which no trouble has been experienced.

The writer is decidedly in favor of using the full hemispherical bottom, as the use of a conical bottom, or of a segment of a hemisphere, introduces a radial, inward pull on this joint which is liable to cause trouble. The writer does not think that the joint suggested in Fig. 3 of your issue of Dec. 5 (repeated here as Fig. 2—Ed.) is properly designed to withstand this radial inward pull.

Fig. 2. Another Form of Joint.
(Repeated from our issue of Dec. 5.)

The stresses in a hemispherical bottom are only one-half what they are in the vertical sides of the tank, but the writer uses the same thickness, thus doubling the factor of safety in the bottom. In the conical bottom the stresses are much larger than they are in the vertical sides of the tank.

The writer is of opinion that in the shop work for the joint between sides and bottom, the pieces should be assembled in the shop and the rivet holes reamed through; also that adjacent pieces of the bottom should be fastened together in the shop, and those of one piece marked from the holes in the other. Yours very truly,

A. Marston.

Iowa State College, Ames, Ia., Dec. 10, 1901.

The Failure of the Water Tank at Fairhaven, Mass.

Sir: Referring to your account on the failure of the Fairhaven water tank, I wish to say that the design of this structure was faulty in every particular. It can easily be proved that the stresses in the conical bottom reached 30,000 lbs. per sq. in., and considering the deterioration of the metal by bending, flanging, punching and eventually bad riveting, the failure was only a question of time. Each of the ¾-in. rivets in the horizontal flanged part of the bottom had to transmit a force of 10,000 lbs., which explains the fact that the tank could never be filled to a depth of 30 ft. without overstraining these rivets and causing leaks.

The design was also faulty in the shape of the tank. It was much too high for the diameter. If a diameter of 50 ft. had been adopted, the height of the cylindrical part could have been reduced to 20 ft. for the same content, thus relieving considerably the stresses in the bottom and making the whole structure a good deal cheaper.

I cannot agree with your correspondent, Prof. A. Marston (Dec. 5), that this was a pioneer structure of its kind. On the contrary, the disadvantages of this kind of tanks, more especially their property to leak at the junction between bottom and sides, were so well known in Europe that they were abandoned about 15 years ago for tanks of more than 10,000 gallons capacity. There was substituted the Intze tank, which has a conical bottom, with one or two counter "bottoms." These structures proved from the very first a great success. They are lighter than the above-mentioned tanks and do not cause leakage at the joints. The counter bottoms may be so arranged to exclude any possibility of bending moments coming on the supporting ring. The fact is that nearly all the water-works of Europe requiring steel tanks have adopted this system. A description of such a structure can be found in a November issue of the "Engineering Record" for last year.

523 Garfield Building, Leopold Mensch.
Cleveland, O., Dec. 8, 1901.

Steel Bonds for Masonry Dams.

Sir: The safeguards to be adopted in designing an engineering structure should be in proportion to the disastrous consequences in case of its failure.

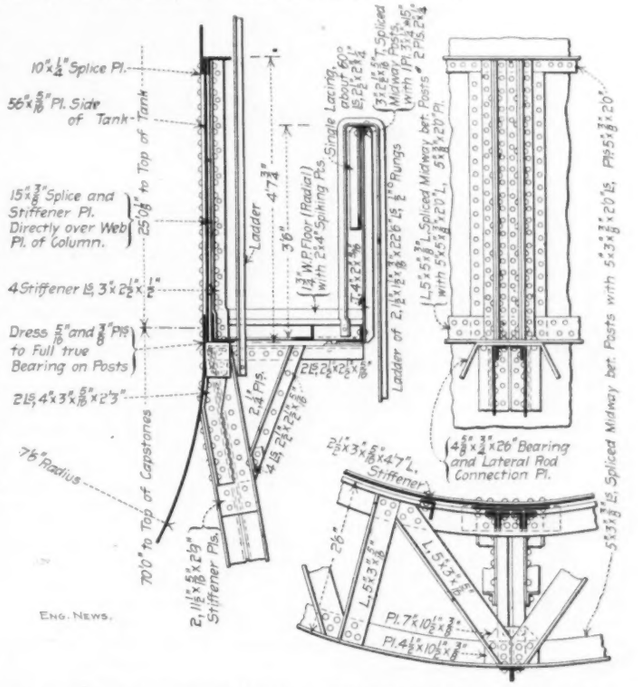

10"x1"x¼" Splice Pl.
56"x⅝" Pl. Side of Tank
Top of Tank
15"x⅞" Splice and Stiffener Pl. Directly over Web Pl. of Column.
25'0" to Top of Tank
4 Stiffener Ls 3"x2½"x⅜"
Dress ⅝" and ⅞" Pls to Full true Bearing on Posts
21 Ls 4"x3"x⅝"x2'3"
75° Radius
70'0" to Top of Capstones
2 Pls ⅝"x5"x29" Stiffener Pls.
Ladder 4'7½"
3'6"
Single Lacing about 60° 8"x2½"
Ladder of 2½"x2½"x⅜" Angles
Eng. News.
Pl. 7"x10½"x⅜"
Pl. 4½"x10½"x⅜"
L 5"x3½"x⅜"
26"
Stiffener
4⅞"x⅞"x26" Bearing and Lateral Rod Connection Pl.
Spliced Midway bet. Posts with 5'3⅜"x20'0", Pls 5'3⅜"x20'0"

FIG. 1. DETAILS OF JUNCTION BETWEEN SIDES AND BOTTOM OF ELEVATED STEEL TANKS.

Prof. A. Marston, Assoc. M. Am. Soc. C. E., Engineer.

Nothing more disastrous can be imagined than the failure of a high reservoir dam. Here every provision that prudence can suggest should be adopted. Viewed in this way, the various designs for the large Croton dams on the Quaker Bridge, as well as on the Cornell site, seem to have provided merely for conditional but not for unquestioned safety.

The region of New York experienced an earthquake of noticeable severity in the fall of 1886. The seismic wave originated, if I remember rightly, in the West Indies and traveled northward along the Atlantic Coast of the United States. Numerous rather small reservoir dams in the Atlantic States were destroyed and caused floods. What assurance have we that this region may not be visited by an earthquake again, severe enough to crack the high masonry dam of the Croton reservoir? It need not be so severe as the unexpected shock which destroyed Lisbon in 1755. If it should be only a few degrees more severe than the earthquake of 1886, it would be sufficient to destroy the masonry dam now building, bring death to tens of thousands, wipe out hundreds of millions of property, and cause a water famine in the then perhaps most populous city on earth.

I have pointed out such a danger before (see Trans. Am. Soc. C. E., Vol 34, p. 505), and the provision which should be made against it. To repeat the advice then given: The dam should not only be safe against overturning and sliding from water getting under its base or into any horizontal crack of the masonry from whatever cause (as Mr. John Van Buren is again pointing out in your issue of Dec. 26, 1901), but the dam should be bound and anchored together by a network of steel buried in the masonry and reaching down into the rock foundation.

About 2,500 tons of steel would have been sufficient for the Cornell Dam, at a cost of $250,000, or about 5% of the estimated cost of the dam. Cracks in that kind of masonry from earthquakes would cause no apprehension. The dam might leak badly, but it could not break up.

If the Austin Dam had been constructed in such a manner, its disastrous failure could not have occurred. It would have cracked, but it could not have slid on its foundation and broken up as it did. No flood would have occurred.

It seems that the lessons taught by the Austin Dam and by the failure of smaller dams along the Atlantic seacoast from the earthquake in 1886 have not been given the grave consideration which they deserve by the designers of the Croton Dam. Gustav Lindenthal.

45 Cedar St., New York, Dec. 27, 1901.

Notes and Queries.

J. M. H. reports the discovery of a bed of basaltic lava in Arkansas at a point about 25 miles north of Little Rock and two miles southeast of Austin, Lonoke county, on the line of the Iron Mountain R. R.

W. P. H. writes that in the letter entitled "Random Notes of an Engineer," published in our issue of Dec. 19, the production of gold from the Cripple Creek mining district in 1891 should have been printed as $200,000 instead of $2,000,000.

The text of the titles to Figs. 4 and 5 in Mr. Craven's article on "The Needless Changes in the Jerome Park Reservoir Construction," in our issue of Dec. 19, were transposed. As the titles stood, the text should have been changed correspondingly in lines 16 and 13, third column, p. 470.

E. M. C. desires information respecting the following: If a brass ferrule be soldered to a copper cylinder, what would be the holding strength of the solder on the brass as compared with the copper, and which would hold the longer? The combination would be exposed to the action of salt water.

Proper credit for descriptive data and cuts was inadvertently omitted in the article on "Difficult Mountain Railway Construction in Switzerland," which appeared in our issue of Dec. 19. It should, in rectification of the omission, be stated that the greater part of the information from which the article was compiled and the material for the illustrations shown, were taken from an article by Chief Engineer Hennings in the "Schweizerische Bauzeitung."

THE GROWTH OF THE TELEPHONE BUSINESS in the United States is shown in the last annual report of the American Telephone & Telegraph Co. At the close of 1891, 512,407 instruments were installed; in 1901, 1,952,412 instruments are in use. The first telephone exchange in the world was opened in the United States less than 24 years ago; and 20 years ago there were 47,880 telephone subscribers and 29,714 miles of wire. At the beginning of 1901 there were 800,880 telephone exchanges in the country, using 1,961,801 miles of wire. The capital invested in this business is put down at $470,000,000 for all companies, with a total of 2,278,717 telephones of all kinds.

SWITCHING YARDS OF THE CHICAGO TRANSFER & CLEARING CO.

(With two-page plate.)

A comprehensive plan for the systematic handling of the vast and complicated interchange of freight cars at Chicago has been carried into effect, and the necessary plant is now practically completed and ready for operation.

The principle embodied in the new transfer yard of the Chicago Transfer & Clearing Co. is the reduction of the great delays and expense incurred by the present transfer system, under which every individual trunk road (and there are 20 of these entering Chicago) makes its own transfers of freight cars to and from the other trunk roads, either directly or through the medium of the various belt and terminal lines. The distance from yard to yard of the several trunk lines varies from ¼-mile to 16 miles. As its name indicates, the new company proposes to operate a general transfer yard, on the "clearing-house" system, centralizing the work at one point in the outskirts of the city, and thus relieving the city lines and yards of much of the traffic which causes their present congestion. Inbound trains arriving at the main yard of one road may have all the through cars switched out and sent direct to the transfer yard for distribution upon separate tracks for the various roads over which they are to be forwarded. In this yard, also, they may be classified according to the requirements of these latter roads.

A project similar to that of the present company, as above outlined, was conceived in 1890 by Mr. A. B. Stickney, now President of the Chicago Great Western Ry. Land was acquired at about the location of the present yards, and the track plan proposed provided for a double-track circle, one mile in diameter, outside of which were to be yards for the various roads, the through cars being transferred from one yard to another over the circular tracks. This project is shown on most of the present maps of Chicago, the site being just west of the city limits and extending between 55th and 79th Sts. The site is still commonly known as the Stickney tract, although the project was abandoned nearly ten years ago, after some preliminary work had been done and a few miles of track laid.

The present transfer yard and system have been established by the Chicago Transfer & Clearing Co., already mentioned, with Mr. A. W. Swanitz as Chief Engineer. An outline of the entire project was given in our issue of June 13, 1901. Warehouses, transfer houses and other facilities may be provided in the future.

FIG. 3. PLAN OF TRANSFER OR SWITCHING YARDS.
A. W. Swanitz, Chief Engr.

GENERAL DESCRIPTION.

The Chicago Transfer & Clearing Ry. Co. controls a tract of land of about 3,700 acres, bounded by 63d St. on the north and 79th St. on the south, and extending from the city limits to the Chicago Drainage Canal. The transfer yard is about on a line with 67th St., and lies between the double track Chicago & Western Indiana R. R. (Belt Line) and the city limits on the east, and the parallel single tracks of the Chicago Junction Ry. and Chicago Terminal Transfer Ry. on the west. The distance between these lines is about 4½ miles, and all three are switching roads connecting the various main lines and their terminals, so that the transfer yards are very accessible. The first yards are now practically completed and ready for operation. They are some 13,000 ft. long and 660 ft. in width.

Although the land is high, it is perfectly level. The site was originally very damp, but has been drained by the construction of a main sewer 4½ miles long, 18 ins. to 90 ins. diameter, along the north side of the property, with 19 laterals across the yard at intervals of 660 ft. The laterals are 12 ins. diameter, with 8-in. branches. This sewer was described in our issue of November 7, 1901. The main sewer has a fall of 22 ft. in its length of 4½ miles, and discharges into an open cut nearly a mile long, leading to the ditch of the Chicago & Alton Ry., which empties through a culvert into the Illinois & Michigan Canal. An industrial village will be established for the accommodation of the employees, and two large boarding houses and several dwellings have already been erected for this purpose. These buildings are of frame construction, and are provided with sewer and water connections and electric light.

TRACK CONSTRUCTION.

The surface of the ground for the first yard was covered with 2 ft. of sand, protected from the wind and from other disturbing influences by a 6-in. bed of slag. The artificial hill for the gravity switching is also of sand, with slopes covered with cinders as a protection. This sand was furnished by the Knickerbocker Ice Co., of Chicago. The tracks are laid with 75-lb. rails of the Am. Soc. C. E. section, spliced with four-bolt angle bars and spiked to oak and cedar ties laid in gravel ballast. The repair tracks are ballasted with cinders. This one group of yards comprises about 100 miles of track, with 422 switches. The switch work comprises 358 split switches (102 electrically operated), 64 slip switches (with rigid frogs), 160 spring rail frogs, 198 rigid frogs, and 68 crossovers.

The split switches, Fig. 1, have 15-ft. reinforced switch rails, connected by a head rod and four switch rods, two of the latter being adjustable. Steel plates extending from the rails to the middle of the track are laid on the tie under the switch points. The throw of the switches is 5 ins.; the switch angle for No. 9 frogs is 8° 18′, and the curve behind the frog has a radius of 692 ft. In front of each switch are guard rails 6 ft. long, straight for a distance of 4 ft., and giving a flangeway of 4 ins. at the outer end and 1¾ ins. at the toe of the switch. The spring rail frogs, Fig. 2, are No. 9, 15 ft. long, with the spring at the throat and a reinforcing bar on the spring rail. Rigid frogs (No. 9) are used on all ladder tracks. They are 12 ft. long (4½ ft. from point to toe and 7½ ft. from point to heel), and have steel filling pieces. Rigid frogs No. 5 and No. 6 are used at crossings. The double slip switches are No. 7. The frog guard rails are 15 ft. long, straight for 6 ft. at the middle, and bent to give a flangeway increasing from 1¾ ins. at the straight part to 2¾ ins. at 1½ ft. from the end, thence flaring to a spread of 6 ins. Each guard rail at switches and frogs is bolted to the track rail at the middle (a filler block being used) and supported at each end by a rail brace.

Dwarf switchstands of the drop lever type are used, with red targets and lamps, and all the switch lamps are fitted with electric lights of 8 c. p. The current is sent from the power house at 2,300 volts over the separate circuits, with transformers at intervals to reduce the current to 110 volts, and from these transformers lead-covered cables (in iron pipe conduits) are run to the switchstands. To facilitate repairs and lamp renewals there will be instruments in the power house showing the number of lights burning on each of the four circuits. The switches of the classification yards are all electrically con-

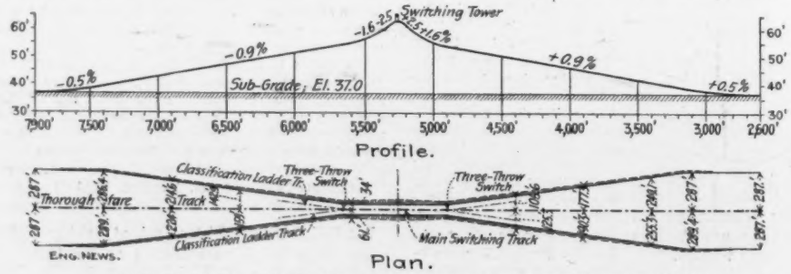
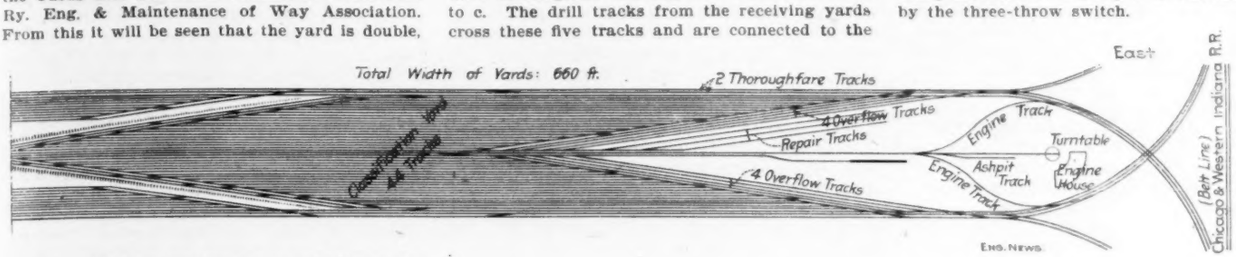


FIG. 6. PLAN AND PROFILE OF HILL FOR GRAVITY SWITCHING.

trolled, as described further on. The switches and frogs are made to special designs prepared by the Chief Engineer, Mr. Swanitz, and were built by the Cleveland Frog & Crossing Co., of Cleveland, O. This company also built the switch-stands.

YARD DESIGN AND OPERATION.

The general plan, Fig. 3, shows the groups of tracks forming the separate yards which together make the "cluster," to use the term suggested by the Yards and Terminals Committee of the Am. Ry. Eng. & Maintenance of Way Association. From this it will be seen that the yard is double, the rails are 24½ ft. above the rail level in the yards below. From the summit there is a grade of 2.5% on each side for a distance of 110 ft., intended to start the cars; this is reduced to 1.6% for 105 ft., and the grade then continues at 0.9% to the bottom, where it is reduced to 0.5%, the connections between the grades being made by vertical curves. At the foot of the grade the classification yard reaches its full width, and beyond this the tracks are level. The hill is 141.5 ft. wide at subgrade and has five tracks, 13 ft. c. to c. The drill tracks from the receiving yards cross these five tracks and are connected to the rear car, pull the train backward out of the receiving yard and then push it up the drill track, which is the outer of the two tracks parallel with the ladder track of the classification yard. At the top of the hill the train will run onto the middle track. During this movement each car or cut of cars will be uncoupled, and as the cars are pushed slowly over the summit the sharp down grade on the opposite side will cause them to run away, passing down the middle track and being diverted to the right or left ladder track by the three-throw switch.



YARDS; CHICAGO TRANSFER & CLEARING CO.
Engineer, Chicago, Ill.

to be operated from each end. On each side are two thoroughfare or running tracks, 15 ft. c. to c., forming the boundary lines. At the east end each pair of running tracks connects with the Chicago & Western Indiana R. R., thus forming two double track Y's. At the west end the two pairs of running tracks (and the central open track) converge into a double track line which connects with the Chicago Terminal Transfer Ry. and the Chicago Junction Ry. by a double track Y. These junctions will eventually be equipped with interlocking switches and signals. From the running tracks open the leads of the two receiving yards, each of which has ten tracks 1,600 to 3,000 ft. long. At the ends of the "cluster" are the two classification yards, each of which has 44 parallel tracks 2,500 ft. long and 13½ ft. c. to c. The inner running track and outer classification track are 15 ft. c. to c. At the outer end of each classification yard are two overflow yards, with four tracks in each, 2,000 ft. long, to relieve middle or main switching track by double slip switches. The middle track extends the full length of the "cluster," forming the approach to the classification yards, a three-throw split switch, Fig. 7, at each end giving access to one or other of the two ladder tracks of each classification yard. Through the classification yards this middle track is maintained as an open or thoroughfare track.

At the center of the hill is a switch tower, on a steel bridge 68 ft. long, spanning the tracks, and from this tower the switch movements for the classification yards are operated. The top chord of this bridge is 29 ft. above the rails. At the middle of the yard are the power house, office building, water tank, etc. At the east end is the roundhouse, and at the west end is a space reserved for repair yards, storage yards, transfer sheds, etc. On one of the overflow tracks at the west end is a Fairbanks & Morse 48-ft., 100-ton, track scale.

Before going over the summit of the grade, each car or cut of cars will be mounted by a brakeman, who will regulate the speed when the car descends the grade on the ladder track and runs onto its proper classification track. An engine running on the open middle track, or on one of the running tracks at the side, will bring the men back in readiness to catch other cars as they come down the grade. Between the drill track and the classification ladder track is a poling track, from which an engine can pole cars which have failed to reach or clear their switches on the ladder track. This will only be necessary in very bad weather or with cars in poor condition. Crossovers are provided between the drill, poling and ladder tracks to prevent any derailment or other accident blocking the operation of the yards.

One drill or pusher track on each side extends across the five tracks on the hill, being connected to each track by a slip switch, and crossovers are also provided between these five tracks. Any cars which are intended for tracks in the classification yard on the same side of the hill as the train with which they are being switched will be run onto one particular track, until a sufficient number has accumulated, when they will be pushed back to the summit and dropped into their respective tracks. Thus only two switching movements will be required. Cars for each individual road will be switched onto certain tracks, and will be arranged as required by the different roads, as, for example: division order, loaded and empty cars, coal and general freight, etc. The

FIG. 5. GENERAL VIEW OF SWITCHING HILL AND TOWER.

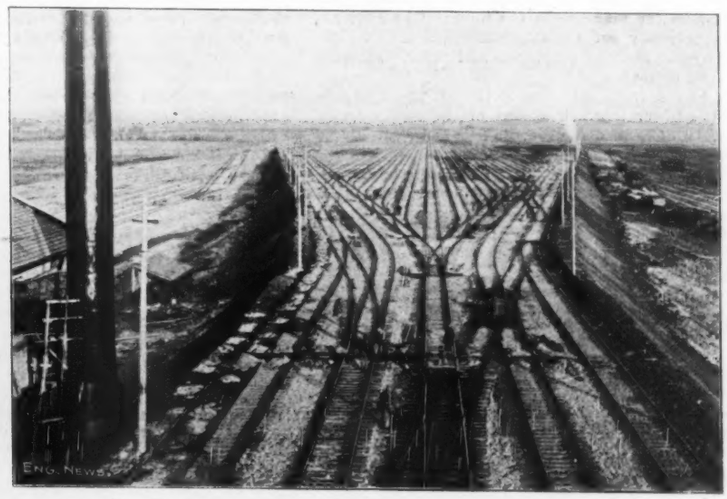


FIG. 9. VIEW LOOKING EAST FROM THE SWITCHING TOWER AT THE SUMMIT OF THE HILL.
(Classification Yard in front. Receiving Yards on either side of the hill.)

classification tracks which may be filled and therefore interfere with the further work of classification.

The yard is of the summit type, in which the movement of cars for switching is produced by pushing them slowly over a summit, beyond which they run by gravity. In the center of the "cluster" is the artificial hill for gravity switching, which is one of the most important features of the plan, and is shown in Figs. 5 and 6. A brick arched subway through the hill affords access to the parts of the yard on either side. This hill is 5,000 ft. long from end to end, and at the summit

To explain the method of operation of the yard, we will assume a train to arrive at the east end, the road engine leaving the train on one of the tracks of the north receiving yard, and taking back a train of cars destined for its own road. While standing in this yard each car will be marked (by card or chalk) with the name of the road to which it is to be delivered. This will be done from the waybill, and a list showing this information, together with the order in which cars for each road are to be arranged, will be given to the operator in the tower. An engine will then be coupled up with its head against the

strings of cars thus sorted in the classification yard can be taken out by the engines of the respective roads, as already described. Fig. 9 is a view looking east over the yard from the signal tower.

It is estimated that with a speed of about 3 miles per hour for switching on the classification tracks from 5,000 to 8,000 cars per day can be received, switched and delivered. For operating this first "cluster" the company has ordered four consolidation engines for pushing trains up to the summit, and two six-wheel switching engines for general work in the yards. The consolidation engines will have cylinders 21 × 26 ins., and driving wheels 51 ins. diameter, and will weigh 185,000 lbs. with 170,000 lbs. on the drivers. The switch engines will have cylinders 19 × 24 ins., driving wheels 51 ins. diameter, and will weigh 120,000 lbs. These engines will be built by the American Locomotive Co.

ELECTRIC OPERATION OF SWITCHES.

The 86 switches in the ladder tracks of the two classification yards and 16 other switches in connecting tracks (102 in all) are operated on the electro-pneumatic system. The cylinders of each switch are supplied with air from a pipe line under a pressure of 60 lbs., and the valves are electrically controlled from the switching tower. In this tower are ten operating machines, each of which can control a group of 12 switches, giving a total capacity for 120 switches. The machines are rectangular cabinets, each having in its face two rows of 12 push buttons and a row of 12 rectangular indicator openings above, there being two push buttons and an indicator for each switch. The lower part of the cabinet is lettered "Reverse," and has black buttons with white figures. The upper part is lettered "Normal," and has white buttons with black figures. The indicator openings are rectangular and behind each is a curved brass plate, on the end of a pivoted arm; the middle portion of the plate is painted red, while the upper and lower parts are marked "Nor." and "Rev." respectively, being colored to correspond with the buttons. The two push buttons are electrically connected with the magnets operating the valves of the air cylinders. Each switch is in an insulated block section, which is electrically connected to the corresponding indicator on the machine in the tower. The switches are normally set for the ladder track, with the "Normal" buttons depressed and "Nor." showing at the indicator of the machine.

When a train is to be switched, the operator in the tower is given a copy of the classification list, as already described, and as each car starts down the grade from the summit he knows for what classification track it is destined. If the car is for track No. 10, the operator pushes the button numbered "10" in the lower or "Reversed" row, thereby opening the switch and causing "Rev." to show at the indicator. When the car enters the insulated section occupied by the switch the indicator changes to a red label, showing that the section is occupied, and this remains until the car has cleared the frog and fouling point. When the "Rev." reappears at the indicator, the operator presses the "Normal" button and thus sets the switch for the ladder track again. If the car fails to clear the switch and so blocks the track, the red shown at the indicator serves to notify the operator of this fact and the poling engine can be promptly ordered to push the car onto the proper track.

The apparatus is similar to that used for the electro-pneumatic interlocking system, except that as the switches are operated independently, and are not interlocked, there is no lock and no locking magnet on the switch cylinder. The system has been in use for some years in the Altoona (Pa.) freight yards of the Pennsylvania R. R. Mr. A. C. Shand, Superintendent of the Altoona Division, informs us that there are 12 tracks in the westbound yard and 35 tracks in the eastbound yard controlled by this system, the 47 switches being operated from the tower. The grade of the switching tracks is 0.5% westbound, and 0.7% and 1% eastbound. The maximum speed of distributing cars is 133 cars per hour, while the average is about 95 cars per hour. The plant for both the Altoona and the Chicago yards was furnished by the Union Switch & Signal Co., of Swissvale, Pa.

POWER HOUSE AND OTHER BUILDINGS.

The power house is a yellow brick and white stone building near the center of the yard, and is 74 × 138½ ft. in plan; it has steel roof trusses and a tile roof. The boiler room is on the ground level and contains three batteries of Babcock & Wilcox water-tube boilers of 300 HP. each, space being left for an additional battery when required. They are fired by hand, and burn soft coal, which is stored at the rear side of the room. A coal storage plant will be established later. The steel breeching from the boilers leads to a steel chimney 125 ft. high and 8 ft. diameter, built outside the house. The engine room is elevated above the ground; it has a tile floor, and a 9-ft. wainscot of white enameled brick, above which the walls have the rough plaster finish.

At one side of the engine room are two "Ideal" tandem compound horizontal engines of 250 HP., each having on its shaft a General Electric 250-K-W. generator. Beyond them is the switchboard. At the other side of the room are three Rand air compressors; two of these, of 200 and 270 HP., have cross-compound Corliss engines; the former supplies air at 100 lbs. receiver pressure for the electro-pneumatic switch operating system, the air-lift pumping system, and the tools in the engine room; the latter is to supply air at 800 lbs. pressure for general power purposes in the transfer houses (not yet built), and about the yards. The third machine is a straight-line compressor of 225 HP., with a capacity of 950 cu. ft. of free air per minute. Near the compressors are two Knowlton duplex steam pumps of 1,000,000 gallons daily capacity.

Near the power house is an office building with two stories and basement, of red pressed brick, with stone trimmings and a tile roof. This is for the use of the superintendent, engineer, master mechanic, yardmaster, and the force of clerks required in keeping the car records. These buildings, as well as the frame hotels and cottages for the employees (already noted) were erected by O'Brien & Dungan, of Chicago.

At the east end of the yard is a roundhouse, 80 ft. wide, which can be extended to have 38 stalls. At present it has nine stalls, eight of which are fitted with engine tracks and pits, while the other will be used temporarily as a machine and repair shop. An annex contains a boiler for driving the hot-air fan and heating the air, and also furnishing water for washing out the engine boilers. The building is of brick, with cast-iron columns and concrete pits, including a drop pit for the wheel jacks. The floors of the pits are convex, and their walls are capped with wooden stringers for the rails. The roof is of wood, covered with a tar and gravel composition, and having the Roe iron swinging smokejacks furnished by the Railway Supply Foundry Co., of Chicago. The building has two large windows to each stall, and wooden swinging doors in the front. It is fitted with the Sturtevant fan system of ventilation and hot-air heating. The roundhouse is served by a 70-ft. turntable built by the Detroit Bridge & Iron Works; this has a concrete pit, drained into the general drainage system of the yard.

Beyond the turntable is a water column, and a 50-ft. cinder pit, with depressed track for the ash cars. This pit has concrete walls and a brick floor, while the rails are bolted directly to I-beams supported by cast-iron pedestals. The side of the pit next to the depressed track is open, so that ashes are shoveled directly into cars. The Western Engineering Co., of Chicago, had the contract for the roundhouse, turntable pit, ashpit, and pedestals for the water tower.

COAL, WATER AND ELECTRIC SUPPLY.

Near the roundhouse is an 80-ton coaling station for the locomotives. This is of the type invented by Mr. E. H. McHenry, M. Am. Soc. C. E., late Chief Engineer of the Northern Pacific Ry. At the back of the structure is a 40-ton receiving pit or hopper, which is built above ground on account of drainage conditions, and is crossed by an elevated track, so that coal can be dumped or shoveled directly into this pit, from which it is fed by gravity to the boot of a link-belt bucket conveyor, which delivers the coal into two 40-ton pockets, one on each side of the conveyor. Chutes on these pockets deliver the coal to the engines. Under each pocket is a 40-ton storage bin, filled through a sliding trap in the bottom of the pocket, when the latter is full. When the coal in these bins is required it is run by gravity back to the receiving pit and the conveyor. Each pocket is suspended eccentrically so as to exert pressure on a dynamometer, from which an oil pipe is led to a dial on the front of the pocket, graduated by increments of 250 lbs. This dial shows the amount of coal in the pocket at any time, and also enables the fireman to see how much coal he is taking.

The water supply of 1,400 gallons per minute is obtained from three artesian wells about 1,600 ft. deep, the water being pumped by the air-lift system to an underground elliptical concrete reservoir, 19 × 36½ ft., 8 ft. deep, with a capacity of 30,000 gallons. From this reservoir it is raised by the steam pumps to a wooden tank of 100,000 gallons capacity on a 12-column steel tower 62 ft. 6 ins. high, the tank being 30 ft. diameter and 20 ft. high. From this tank the water is distributed through the yards by a system of 10 miles of mains, 12 to 6 ins. diameter, with connections to 61 hydrants and 15 water columns at various parts. For fire services, the tank supply can be shut off and water pumped directly into the mains. The water columns are 10 ins. diameter. The coaling station, water tank and water columns were built by Fairbanks, Morse & Co., of Chicago.

The electric light system includes incandescent lamps (16 c. p.) and ten arc lamps (1,600 c. p.) in the buildings, 450 incandescent lamps of 8 c. p. in the switchstands, and 85 enclosed arc lights of 1,600 c. p. for lighting the gravity switching tracks and classification yards. These arc lamps are placed on poles 35 ft. high, at intervals of 300 ft. on each side of the switching hill, being fitted with shades on the side next to the switch operating tower, so as not to dazzle the operators in the tower or the brakemen riding the cars. The poles carrying the telephone and telegraph wires are 100 ft. apart, with an arc lamp on every third pole near the switching tracks and at greater intervals in other parts of the yard.

A ROCK-FILL DAM WITH STEEL CORE ACROSS EAST CANYON CREEK, UTAH.

By W. P. Hardesty, C. E.*

The enterprise about to be described is a good example of one feature in irrigation development and settlement of the arid west to which not nearly enough attention is usually paid. Generally the irrigation projects for rendering available and utilizing large supplies of water are started in almost entirely new and unsettled localities. Under such conditions the process of settlement and cultivation of the lands is usually very slow and uncertain, and the irrigation company finds that colonizing the country under its canal system is a very much greater task than building the water supply works.

Indeed, about nine out of every ten of the corporate enterprises of this kind have been positive failures, the investors receiving no returns for their outlay. In the case of a well-settled locality, where the resources of the country are well developed, and there are good markets nearby for the products of the irrigated farms, the value of a certain quantity of water becomes much greater.

When so much land comes under cultivation that some of it must suffer from a scarcity due to there being not enough water to go around, the value per unit of the latter becomes greatly increased, and the demand for any new supplies developed is at once quick and certain. This is a very important aspect of irrigation, the influence of which has of late years become more recognized.

The Davis and Weber Counties' Canal Co. is composed of farmers in the country tributary to Ogden, Utah. It owns a canal of a capacity of 125 sec. ft., heading in the Weber River in Weber Canyon (ten miles southeast of Ogden). The canal extends along the steep hillside on the south side of the river for a distance of nine miles, to the top of the bench or mesa, five miles south of Ogden.

*Progress Building, Salt Lake City, Utah.

Here it is divided into the north, west and south branches. The north branch is used to irrigate lands lying west of Ogden. The west and south branches are used to irrigate lands lying between the foot of the mountains and the east shore of the Great Salt Lake, extending from Ogden for a distance of 15 miles south to the town of Kaysville, along the lines of the Rio Grande Western and the Oregon Short Line railways, comprising 12,000 acres of the choicest lands in this great valley, well-suited for all kinds of grain, and more especially for all kinds of fruit grown in this climate.

This company, being one of the late appropriators of the waters of the Weber River for irrigation, was entitled to a portion of the natural flow of the river only when there was a surplus, so when the low water season commenced (usually about July 1) it was compelled to close its headgate and do without water the remainder of the season, or else rent the use of water from other owners.

In this section no fruits can be grown on any of the lands without water for irrigation the entire season, and but one crop of hay can be grown with surplus water only. With water for the entire irrigation season, three crops of hay and all kinds of fruit can be grown. To provide water for irrigation during the latter part of the season, the company resolved to build a reservoir in which to store the spring floods. A suitable site, Figs. 1 and 3, for a reservoir was found on East Canyon Creek, the largest tributary of the Weber River. This is in Morgan Co., Utah, at a point 27 miles above the headgate of the canal and about 20 miles northeast of Salt Lake City. The creek rises in the mountains, near Park City (one branch only ten miles east of Salt Lake City), and flows in a northerly direction a distance of about 25 miles to the junction with the Weber, near Morgan City. It runs along the eastern base of the Wasatch range, the Salt Lake valley being across the range on its western side. A few miles below the junction the Weber turns to the west and cuts through the Wasatch range (running through a canyon) and debouches into the Salt Lake valley.

East Canon Creek has a drainage area of 300 square miles and a maximum flow of 1,200 sec. ft The mean flow for the months of February, March, April and May (the season of greatest surplus) is about 300 sec. ft., while the minimum flow in the late summer and fall is 10 sec. ft. At a point about twelve miles above the junction with the Weber, the stream, after passing through a valley, enters and flows through a canyon for a distance of 600 ft. The walls of this are of conglomerate rock and are quite steep.

The valley above the canyon is 800 ft. wide, extending up the stream for several miles at a slope of 30 ft. to the mile. The sides rise at the rate of about 1 on 4. At the upper end of the short canyon is the point selected for the dam, which is at an elevation of 5,610 ft. above sea level, 1,400 ft. higher than the surface of Great Salt Lake.

Surveys for the dam and reservoir site were first made in 1894, under the direction of L. E. Adams, then president. Approval of the government of the application for right-of-way was secured the next year.

In 1897 the company secured the services of W. M. Bostaph, of Ogden, as chief engineer, and of Samuel Fortier, then professor of civil engineering in the State Agricultural College, as consulting engineer, and preparations were made to begin construction.

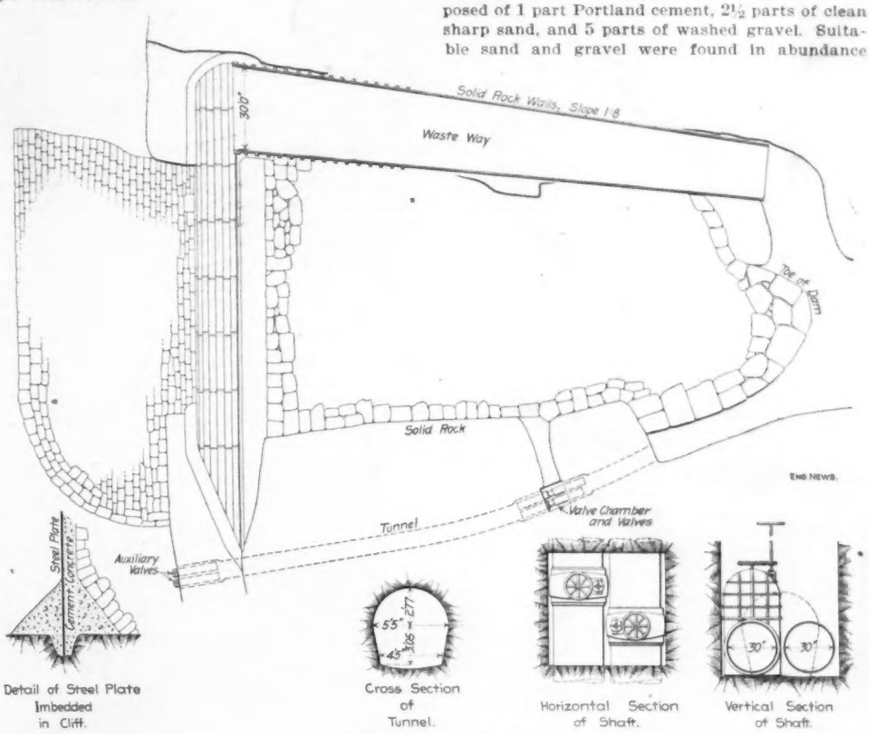


FIG. 1. PLAN OF DAM.

DAM.—A temporary dam was built about 1,000 ft. above the canyon; a canal was then built around the hillside, with flumes in the canyon, and the water was carried and discharged below the dam. An excavation 15 ft. wide was then made across the canyon, which at this point is 54 ft. between side walls at the surface of the ground. At a depth of 35 ft. bed rock was encountered and found to be solid and a perfect foundation for a dam. It was found that the excavation uncovered what had once been the upper end of a cataract, the water having dropped over a ledge to an unknown depth. Soundings for 30 ft. below the excavation, just below the ledge, failed to uncover bed rock.

The great distance to bed rock at the point where the downstream toe of a masonry dam would necessarily be located, made this form of dam impracticable. The type of dam known as "rock-filled" was decided on, the center core to be of steel plate imbedded in concrete.

The first step now was the putting in of the concrete foundation, which is also a cut-off wall. The bed rock was cleared of all loose materials, and, as it was very smooth from the action of water in past geologic times, the bottom and sides were roughened by blasting out several hundred cavities and filling them with a concrete composed of 1 part Portland cement, 2½ parts of clean sharp sand, and 5 parts of washed gravel. Suitable sand and gravel were found in abundance within 2,000 ft. of the dam site. This part of the work was completed in March, 1898, and in August a contract was let to Perham Bros. & Parker, of Butte, Mont., to build the dam. This, as originally built, was 68 ft. high above the gravelly bed of the creek and 58 ft. above the bottom of the outlet tunnel. The steel plate center wall, Figs. 1 and 2, is composed of plates 5 × 20 ft. in size, riveted together. There are three tiers or rows of sheets. The bottom tier is 20 ft. high and ⅜-in. thick; the middle one is 20 ft. high and 5-16-in. thick; the top one is 28 ft. high and ¼-in. thick. The whole is riveted and calked water-tight and covered with two coats of refined asphaltum. The foot of the bottom tier is riveted between two angle bars 3 × 4½ × 5-16-in., with ⅝-in. rivets spaced 3 ins., to rest on the concrete foundation. This tier extends across the canyon and 1½ ft. into a trench blasted into each side wall. The

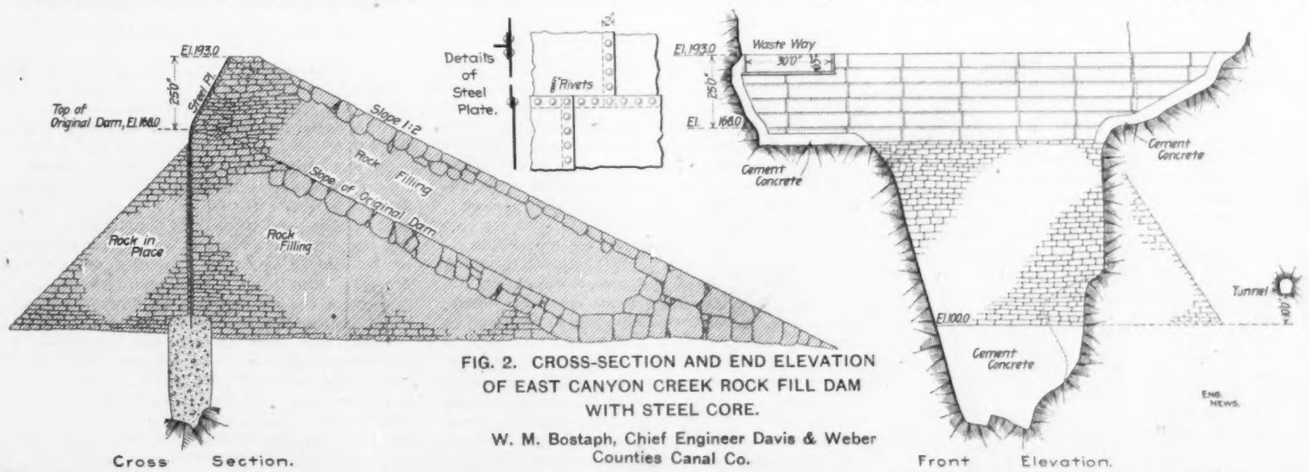


FIG. 2. CROSS-SECTION AND END ELEVATION OF EAST CANYON CREEK ROCK FILL DAM WITH STEEL CORE.

W. M. Bostaph, Chief Engineer Davis & Weber Counties Canal Co.

steel center is imbedded between two walls of asphaltum concrete, each 4 ins. thick. These walls are increased in thickness at the ends of the dam to 4 ft., to make a more secure joint with the side walls of the canyon. This concrete is composed of 30% sand and 70% of gravel mixed with refined asphaltum, allowing 8 lbs. of asphaltum per cu. ft. of mixed sand and gravel. The whole was mixed while heated to a temperature of 300° F., and deposited and rammed into place while hot.

The bottom of the steel wall for a distance of 5 ft. up was imbedded in cement concrete. On each side of the core of steel and asphaltum concrete, a dry rock wall was built up, the stones being carefully laid and bonded, with all the spaces filled with broken rock. Each wall is 20 ft. in thickness at the bottom and 10 ft. at the top. On the upstream side of the dam a face wall 5 ft. in thickness is laid on a slope of 1 to 1. On the downstream side the face wall is the same thickness and laid on a slope of 2 to 1. The portion of the dam between these walls and the walls next to the core, is filled with rock dumped in, with all the spaces carefully filled. The rock for all this work was procured by blasting it from the sides of the cliffs on either side of the canyon. This fell in huge masses, many containing from 500 to 1,000 cu. yds. each. The blasting was done before the core was built up. The rock that fell on and near the concrete foundation was removed and the latter cleaned of all materials; the steel plate wall was then set in position and the asphaltum concrete and the cement concrete around the bottom deposited and rammed. The walls were built of large stones hoisted into position with derricks.

OUTLET TUNNEL.—At a point 70 ft. to the right of the north end of the dam is the upper portal of the outlet tunnel. This is 190 ft. long and excavated through the solid rock side wall of the canyon. The discharge is below the lower toe of the dam. The tunnel is oval in form, 6 ft. in height and 5 ft. in width.* At about 130 ft. from the upper portal a shaft 8 ft. square extends from the cliff above down to the floor of the tunnel. Above a point 20 ft. above the roof this is simply a vertical approach cut to the shaft proper. Two 30-in. valves are placed in this chamber, each connected to two 30-in. cast-iron pipes, which extend into the tunnel each way. These are imbedded in a wall of cement concrete, which securely closes the tunnel against the passage of water except through the valves and pipes. Stems attached to the valves, reach to an operating platform built on top of the valve chamber. Two auxiliary valves, in all respects like the main valves, are placed at the upper portal of the tunnel, attached to 30-in. steel pipes extending 12 ft. into the tunnel. These valves, also, are imbedded in cement concrete. Stems reach from the valves to an operating platform attached to the side of the cliff above the surface of the reservoir. All the large valves have hand wheels at the tops of the stems. A 6-in. pipe is laid through the concrete at the upper portal, in which is a valve with a stem reaching to the platform of the auxiliary valves. This 6-in. pipe is used for refilling the tunnel and removing the pressure from the front of the auxiliary valves when repairs to the main valves become necessary. A 5-in. pipe fitted with valves connects the tunnel on the upper side of the valve chamber with the latter, extending up it to a point above the water level of the reservoir, serving for the escape of air when the tunnel is being refilled after making repairs.

WASTEWAY.—A wasteway 30 ft. wide and 6½ ft. deep is provided, being located on the south end of the dam. A flume constructed of lumber, resting on a shelf built into the side wall of the canyon, extends 190 ft. on a grade of 1 in 8 to a point beyond the toe of the dam, and discharges the surplus water over and against a rock cliff below the dam.

The dam and the rest of the work were completed April 1, 1899. In the construction there were used: 23,000 cu. yds. of rock; 810 cu. yds. of cement concrete; 183 cu. yds. of asphaltum concrete; 69,800 lbs. of steel; 50,500 ft. B. M. of lumber. The total cost was $60,200.

The area of the surface of the reservoir at 58 ft. above the bottom of the tunnel is 225.4 acres, and the capacity is 167,500,000 cu. ft., or 3,845 acre-ft.

The water in the reservoir was rising rapidly at the time of the completion of the dam, and within two weeks thereafter was discharging through the wasteway. About six weeks after this the valves were closed and the leakage was measured. This was found to be 2.7 sec. ft., coming through innumerable small seams through the rock cliffs on each side of the dam. The company began drawing on the reservoir for its canal on July 5, 1899, using 50 sec. ft. During the winter of 1899-1900 but little snow fell in the mountains, and all the streams the following summer became very low. The company opened its reservoir gates on June 22, and supplied its customers with water for two months, at a time when other canals were dry.

The dam was now examined with a view to raising it 25 ft. higher. It was found in good condition, with no injury to the steel plate that could be seen, although the dry rock on each side of it had settled about 1 ft. A contract was now prepared by the chief engineer for the work of raising the dam to 83 ft. above the outlet tunnel. The plans for this addition, Figs. 1 and 2, were on lines somewhat different from those for the original dam. The old plate at the top having been forced out of line about 1 ft. by settlement of the rock, the latter was removed for a depth of about 10 ft., and the plate put into position. At horizontal intervals of 10 ft., tee bars were riveted to the plate, and these bars were bent to a 20-ft. radius, just above the top of the plate, and made to lean at an angle of 30° from the vertical, to the downstream. They reach to the top of the new dam. The new steel plate is riveted to these, the joints calked and beveled, and the whole covered with two coats of refined asphaltum. The downstream slope of the dam was retained at 2 on 1, and the new slope wall made 5 ft. thick, as before. After the steel plate was raised the wall immediately back of it was built. This wall leaves a space of 1 ft. between it and the plate, which space is widened out to 5 ft. next to the side walls of the canyon. The wall is 20 ft. thick at the bottom and 10 ft. at the top. The space between the wall and the plate is filled with cement concrete. At each end of the steel plate a trench 2 ft. deep is blasted into the canyon wall, into which the plate extends. A cement concrete block of triangular form encloses the end. Each tee bar is anchored into the rock wall of the dam by ⅝-in. steel wire cables, placed at vertical intervals of 10 ft. On the upstream face of the steel plate bolts project at intervals of 8 ft., horizontally and vertically, by means of which heavy planks are bolted to the face. A plank covering is nailed on to these, thus protecting the plate from the heat of the sun and injury from rocks falling from the cliffs on either side. On the shelf on which the old wasteway rested, masonry laid in cement is built up to a height of 25 ft., with a width of 35 ft. This reaches to the bottom of the new wasteway, which rests on and is anchored to it. This wasteway is like the original one, only that it has a slope of 1 to 5.

In this addition to the dam there were used: 16,000 cu. yds. of rock; 410 cu. yds. of masonry; 370 cu. yds. of concrete; 62,000 lbs. of steel; 20,000 ft. B. M. of lumber. The total cost of the addition was $35,500, making the cost of the structure as is now stands $95,700.

The area of the reservoir was increased to 262 acres, and the capacity to 387,500,000 cu. ft., or about 8,900 acre-ft., for a total height of 84.6 ft. above the bottom of the tunnel. The dam is now: Maximum height, 93 ft.; maximum width at base, 289 ft.; width on top, 10 ft.; length on top, 173 ft. The enlargement was made during the winter of 1900-01. The gates were closed March 27, and on May 7 water commenced running over the spillway.

When water is drawn from the reservoir, it runs down the natural bed of the creek to the Weber River and mingles with the waters of it. The proper proportion is then diverted at the headgate of the canal, which is 15 miles below. This canal has much difficult country to run through before leaving the canyon and hillside, and long stretches of it are flumed.

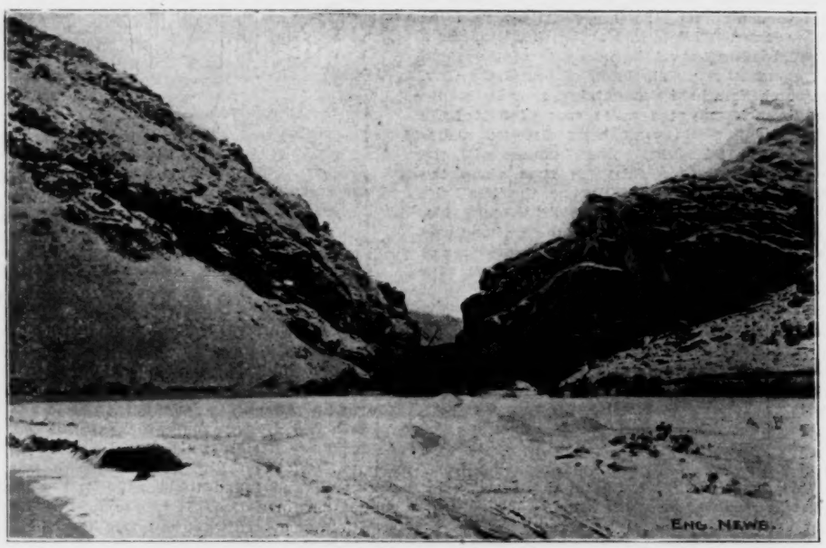
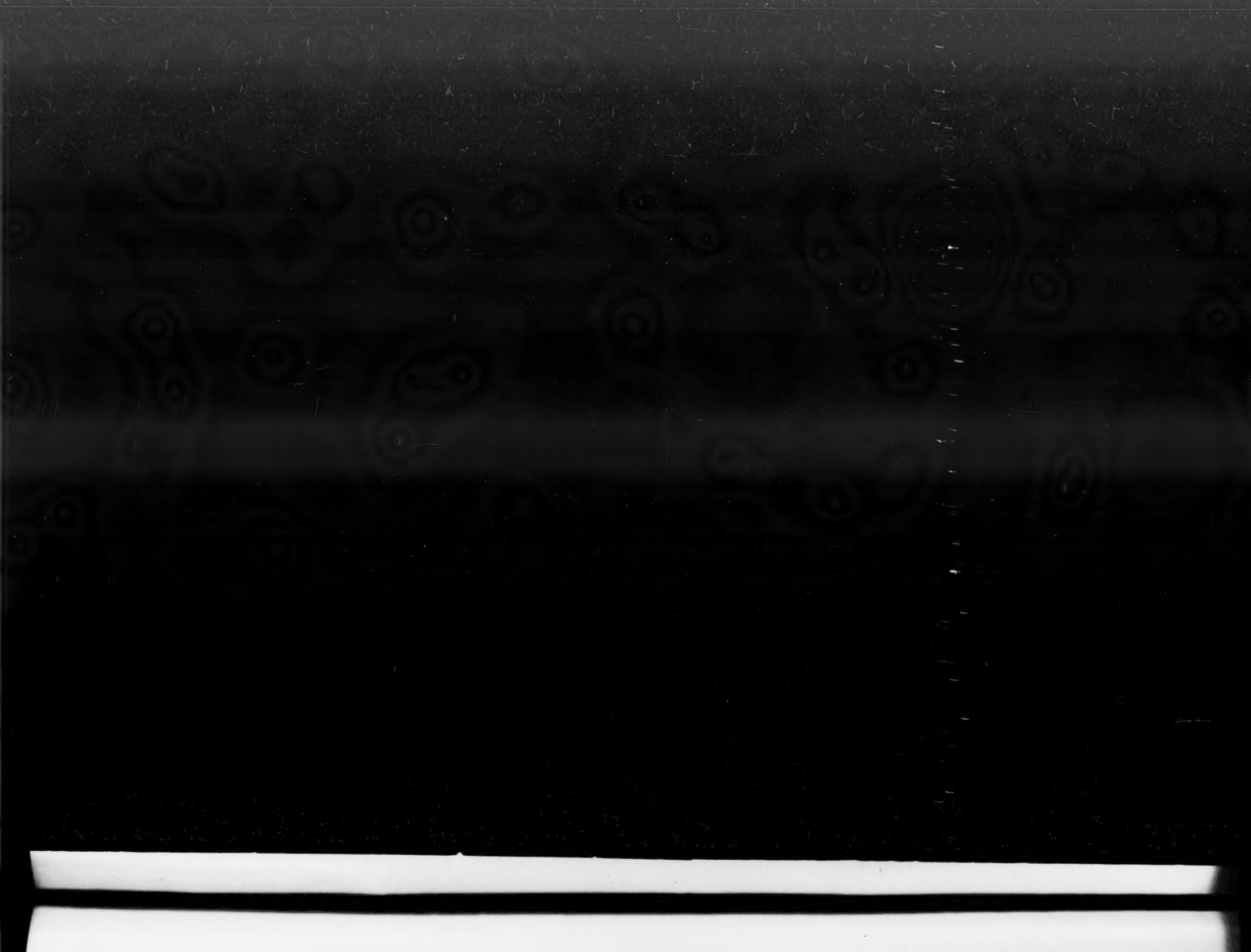


FIG. 3. VIEW FROM ABOVE OF EAST CANYON CREEK DAM UNDER CONSTRUCTION.

For the year 1900 it was estimated, from information obtained from a large percentage of the irrigators, that the value of the crops produced by the water drawn from the reservoir was about $40,000.

During the season of 1901, the reservoir has proved all that was expected of it, furnishing 70 sec.-ft. of water for 60 days, making three full crops of hay, and more than doubling the producing capacity of the land under it. One peculiarity has developed, viz.: the pressure of the water forces it into some underground reservoirs, so that when the water is drawn down these reservoirs empty into the main reservoir, adding an amount equal to or greater than the amount lost by evaporation and other causes. The amount thus added seems to be 5 or 6%, or greater.

Arrangements are now being made to still further increase the height of the dam to probably 150 ft. in the near future, increasing the reservoir capacity to about 1,000,000,000 cu. ft.

The whole work, from the original surveys made in 1894 to the present time, has been carried out under the immediate supervision of Mr. W. M. Bostaph, the chief engineer of the company. All the work, except the early surveys and the putting in of the foundations, has been done during the presidency of Mr. E. P. Ellison, of Layton, Utah.

*The original drawings show a width of 5 ft. 5 ins.—Ed.